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AN
ELEMENTARY TREATISE
ON
MINERALOGY AND GEOLOGY,

DESIGNED
FOR THE USE OF PUPILS,—FOR PERSONS, ATTENDING LECTURES
ON THESE SUBJECTS,—AND AS A COMPANION FOR
TRAVELLERS

IN
THE UNITED STATES OF AMERICA.

ILLUSTRATED BY SIX PLATES.

BY PARKER CLEAVELAND,

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SOCIETY OF DRESDEN, &c.

.....itum est in viscera terræ;
Quasque recondiderat, Stygiisque admoverat umbris,
Effodiuntur opes..... OVID.

SECOND EDITION,—IN TWO VOLUMES.

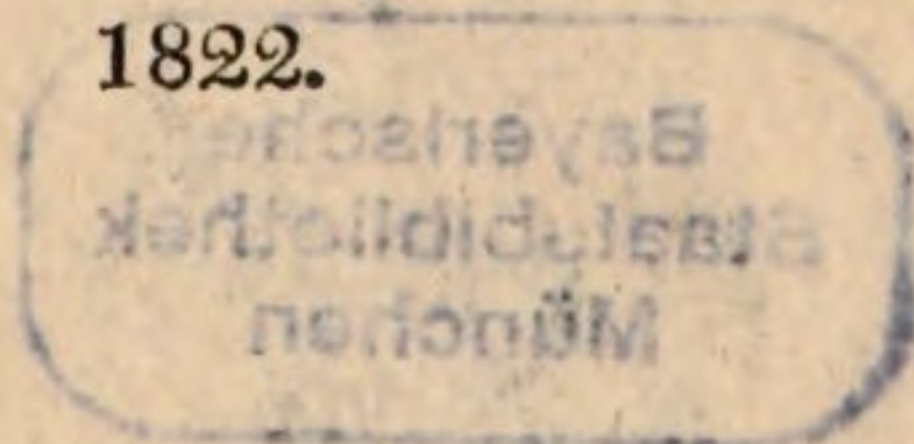
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DISTRICT OF MAINE, ss.

Be it remembered, that on this sixth day of June, A. D. 1822, and the forty sixth year of the independence of the United States of America, *Parker Cleaveland*, of the District of Maine, has deposited in this office the title of a Book, the right whereof he claims as author, in the words following, *viz*;

"An Elementary Treatise on Mineralogy and Geology, designed for the use of Pupils,—for persons, attending Lectures on these subjects,—and as a companion for Travellers in the United States of America. Illustrated by six plates. By Parker Cleaveland, Professor of Mathematics and Natural Philosophy, and Lecturer on Chemistry and Mineralogy, in Bowdoin College; fellow of the American Academy; member of the American Philosophical Society; of the American Geological Society; corresponding member of the Linnæan Society of New England; of the Academy of Natural Sciences of Philadelphia; honorary member of the Lyceum of Natural History of New York; member of the Wernerian Natural History Society of Edinburgh; of the Geological Society of London; fellow of the Mineralogical Society of Jena; of the Mineralogical Society of Dresden, &c.

..... *itum est in viscera terræ;
Quasque recondiderat, Stygiisque admoverat umbris,
Effodiuntur opes.* Ovid.

Second edition, in two volumes."

In conformity to the act of the Congress of the United States, entitled, "An act for the encouragement of learning, by securing the copies of maps, charts, and books, to the authors and proprietors of such copies, during the times therein mentioned;" and also to an act, entitled, "An act, supplementary to an act, entitled, An act for the encouragement of learning, by securing the copies of maps, charts, and books, to the authors and proprietors of such copies, during the times therein mentioned, and extending the benefits thereof to the arts of designing, engraving, and etching historical and other prints."

JOHN MUSSEY, Jun.
Clerk of the District Court of Maine.

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ELEMENTARY TREATISE

ON

MINERALOGY.

CLASS III.

Combustibles.

ALL the minerals, which belong to this class, combine with oxygen, and undergo combustion. Their physical properties sufficiently distinguish them from metals, which, strictly speaking, are also combustibles.—They are sometimes gaseous, sometimes liquid, and sometimes solid. In general, they have a low specific gravity, and are easily broken. They are seldom crystallized. Their colors, in most cases, depend on the nature of the mineral, are hence few in number, and form important characters; they are usually some shade of black, brown, or yellow.

Carbon, hydrogen, and sulphur, either singly or in combination with each other, constitute the principal ingredients of these combustibles; a little oxygen, or iron, or some earth is often present.

SPECIES 1. HYDROGEN GAS.

This gas is twelve or thirteen times lighter, than atmospheric air. It takes fire on the approach of flame, and burns silently, unless mingled in certain proportions with air or oxygen, in which cases it burns with an explosion. This gas, seldom or never found pure, usually holds carbon or sulphur in solution, thus forming the two following subspecies.

SUBSPECIES 1. CARBURETTED HYDROGEN GAS.

It is lighter than air, but heavier than pure hydrogen gas. The color of its flame is bluish, yellowish white, or white, according to the intensity of the combustion, and the proportion of carbon, &c. When exploded with air or oxygen, the products are water and carbonic acid.—It is composed of hydrogen, carbon, and, perhaps in most cases, of oxygen; and is often mixed with carbonic acid, or common air.

This gas is often disengaged from wet marshes, where vegetables are decomposing; it is found also in caverns in volcanic countries; also in mines, particularly of coal, and is by miners called *Fire damp*.—In Italy, near Pietramala, this gas constantly issues from a space about 6 feet in diameter, covered with loose fragments of limestone, &c. The flame appears on and between these stones; has a clear yellowish white color; and rises in very dry weather only a few inches, but, after wet weather, it sometimes ascends two feet above the ground. (*FERBER*, quoted by Murray.)

SUBSPECIES 2. SULPHURETTED HYDROGEN GAS.

This gas is a little heavier than air, and has a peculiar odor, somewhat resembling that of rotten eggs. It burns with a bluish or reddish blue flame, and deposits sulphur on the sides of the vessel. Mixed with about an equal bulk of oxygen gas, it burns with explosion, producing water and sulphurous acid; but with a small quantity of common air it burns without explosion. It is absorbed by water, which hereby acquires the odor of the gas, and a nauseous taste. It precipitates metallic solutions, and tarnishes the white metals; hence it blackens paper, which has been previously dipped in a solution of acetate of lead.—It is composed, as its name indicates, of hydrogen and sulphur.

It is frequently found in places, where pyrites are decomposing; in pits of water, which contain putrid animal substances; and in caverns near beds of volcanic sulphur.

This gas is very abundant in certain mineral waters, and characterizes those, which are called hepatic or sulphuretted waters; such as the Harrowgate water, in Yorkshire, England.—Similar waters exist in many parts of the *United States*, and are sometimes strongly impregnated with the gas.

Sulphuretted waters often contain saline ingredients. They are drunk as deobstruents, or applied externally in cutaneous diseases.

(*Localities.*) The two gases just described are most abundant in volcanic countries, or in mines; but they are by no means confined to such situations. Hydrogen gas is disengaged in many places in Italy, particularly in the environs of Modena, Barigazzo, &c.—In France, near St. Barthelemi, department of Isere, a gas issues from a pond and from fissures in the surrounding earth; it has no odor, but takes fire on the approach of a lighted candle, and sometimes continues to burn for several months. It proceeds from a gray, friable, argillaceous slate, and the mountains in the vicinity are calcareous.—Near the Caspian sea, an inflammable gas issues from the earth in such abundance, that the inhabitants employ it as fuel

for preparing their food, or even for burning limestone. (*BRONGNIART.*)—In Campania, is a spring, whose waters, impregnated with sulphuretted hydrogen, sometimes fail; and the gas then rushes with violence from the earth.

In the *United States*. In *Virginia*, on the banks of the *Great Kenhawa*, near the mouth of the Elk, is a large mass of soft, black earth, into which a pole may be thrust 10 or 15 feet; and from these apertures often proceeds a stream of carburetted hydrogen gas, which will continue to burn for some time. (*MACLURE.*)—In *Ohio*, carburetted hydrogen gas often issues from fissures in shale or secondary argillite. When the auger, in boring for salt wells, enters one of these fissures, water and earth are sometimes thrown up above the surface. These apertures sometimes continue to *blow*, as it is called, for several days; and in some cases the tubes in the well are compressed or filled up. (*ATWATER.*)—In *New York*, at Honeoye, Ontario County, an inflammable gas proceeds from a fissure in a friable, slaty rock, whose surface is covered with a bituminous substance. This gas has the odor of putrid eggs, takes fire on the approach of a lighted taper, and burns with a bluish flame, yielding a smoke, whose odor is like that of burning coal. The earth above the rock resembles that, on which a coal-kiln has been burned, and, when wet, adheres closely to the shovel, with which it is removed. (*Lit. and Philos. Repert. v. i.*)—Between Chippewa and Niagara Falls, at Steel's mills, an inflammable gas issues from the earth in several places very abundantly. (*Dr. R. WEBSTER.*)—In the town of North-East, Dutchess County, is a small lake, from the bottom of which proceeds a very pure inflammable gas. (*AKERLY.*)

SPECIES 2. SULPHUR. *KIRWAN.*

Natürlicher Schwefel. *Werner.* Prismatic Sulphur. *Jameson.* Soufre. *Hauy.* Brongniart. Le Soufre natif. *Brochant.* Schwefel. *Hausmann.* Sulphur. *Aikin.* Phillips.

This mineral is easily recognised. Its usual color is yellow with a shade of green more or less distinct, and forming what is called sulphur yellow. It also exhibits other shades of yellow, being sometimes lemon or wax yellow, and sometimes orange, honey, or straw yellow; when impure, it is often brownish or grayish. It is sometimes opaque, usually translucent, and very rarely transparent. It possesses double refraction in a high degree.

Its specific gravity is about 2.00; and by friction it acquires negative electricity. It is very brittle, and sometimes friable. When heated by firmly pressing it in the hand, a crackling noise is distinctly heard. It is tasteless, and has little or no odor, unless rubbed or heated.

Sulphur most commonly occurs in amorphous, compact masses, whose fracture is uneven, or conchoidal, or a little splintery, with a lustre usually more or less shining, and between resinous and adamantine.—Sometimes it appears in small fragments or grains, disseminated in other minerals.—Sometimes also it is *pulverulent*, existing in the state of a loose, or slightly cohering, dull powder in the interior of other minerals, or attached to their surface, particularly to that of lava.—In some instances its masses are radiated; and, when *volcanic*, it sometimes appears in stalactical concretions, or under some other imitative form.

Sulphur occurs also in regular crystals, whose predominant form is an elongated octaedron (Pl. IV, fig. 32.), composed of two four-sided pyramids, whose bases are rhombs, and whose sides are scalene triangles. This is the primitive form; and nearly all its secondary forms, which are not less than eight, are produced by truncations, applied to the summits, edges, or angles of the primitive. One of these forms is represented in Pl. IV, fig. 33, where the truncation on the common base of the two pyramids is so large, that the crystal may be viewed as a four-sided prism, terminated by four-sided summits. Sometimes the octaedron is cuneiform;—or each summit is replaced by a four-sided pyramid. These crystals, usually small, have in some cases a diameter of five inches; their surface is smooth and shining.

(*Chemical characters.*) When its combustion is slow, the flame is bluish with a suffocating vapor, which is sulphurous acid. But, when the combustion becomes rapid, the flame is white; there is less odor, and the product is sulphuric acid. Native sulphur is often contaminated with certain earths.

(*Geological situation and Localities.*) Sulphur is sometimes found in primitive rocks. Thus at Schwartzwald, in Suabia, it is in veins of pyritous copper, which traverse granite.—In the province of Quito, a bed of quartz, containing sulphur, is found in a mountain of mica slate; and in the same province are two sulphur mines in primitive porphyry. (*HUMBOLDT.*)

But Sulphur, when its origin is *not volcanic*, is found most frequently in secondary rocks, particularly in gypsum, and those minerals, which usually accompany gypsum. It exists in irregular masses, or in crystals, or in veins, and sometimes in beds, varying from a few inches to several yards in thickness. Thus in Sicily, in the vallies of Noto and Mazzaro, it occurs in horizontal beds from two feet to more than ten yards in thickness, alternating with beds of gypsum, and accompanied by sulphate of strontian; here also are found the largest crystals of Sulphur.

Sulphur is almost always accompanied by two or more of the following minerals, viz. gypsum, muriate of soda, marl, or clay; it is thus found at Bex in Switzerland; in the island of Sicily; at Wieliczka in Poland, &c.—Sometimes it is contained in carbonate of lime, or in sandstone. It has, in fact, been observed in most places, where salt mines or salt springs exist.

In Spain, at Conil near Cape Trafalgar, fine crystals occur in cavities in gypsum and clay.—In Arragon and Murcia, it forms beds three or four inches thick in gypsum and marl.—At Poligny, department of Jura, France, Sulphur in a loose or slightly indurated state is embraced in the interior of lenticular masses of flint. It is a little mixed with silex.

Sulphur, in crusts or thin beds, is sometimes found on the surface of the soil in the vicinity of springs, whose waters contain sulphuretted hydrogen gas, which, when exposed to the air, deposits its Sulphur. In Siberia, such deposits are sometimes worth collection.—It may also proceed from the decomposition of animal substances, or of sulphates.

In *volcanic* countries, Sulphur is very common. It is found in the fissures and cavities of lava near the craters of volcanoes, by the heat of which it has been sublimed. It exists in a state of powder, or in crusts, or in irregular masses, or in crystals, or in concretions, globular, stalactical, &c.—Of volcanic sulphur mines that of the Solfa terra near Naples is one of the most remarkable. It is a plain, of which the greatest diameter is about 400 yards, surrounded on all sides by steep rocks, and appears to have been the crater of an ancient volcano. The earth is still warm, and through its crevices Sulphur, muriate of ammonia, &c. are sublimed. Large masses of Sulphur are sometimes attached to the sides of the rocks. M. Brieslak supposes this Sulphur to arise from the decomposition of sulphuretted hydrogen gas, which is here very abundant.—In Iceland, it is sometimes found in large masses near the surface of the soil, and the earth, which contains it, is constantly warm.—In the islands of Guadaloupe, Martinique, Teneriffe, Java, &c.—In the Souffriere of Montserrat, Sulphur sublimes through the fissures of an argillaceous porphyry. The heat is so great, that water, running on the surface, is rendered boiling hot. (*Dr. NUGENT.*)—In the island of St. Michael, near the Hot springs, forming incrustations on the sides of crevices in the earth, and on surrounding minerals. Fine crystals of Sulphur are found lining the interior of fossil reeds, which there form a horizontal bed. (*WEBSTER.*)—In the Island of Java, in the crater of the extinct volcano of Mount Idienne, where is now a lake of sulphuric acid, native Sulphur is said to be abundant. (*SILLIMAN'S Journ. vol. i. p. 58.*)

In the *United States*. In *Virginia*, at the coal mines near Richmond, it rises in fumes through fissures in the earth, and is deposited in acicular crystals at the orifices, from which it issues. (*GRAMMER*.)—In *Pennsylvania*, Montgomery County, at Barren Hill, it occurs granular or pulverulent in reddish white quartz, and originates from the decomposition of sulphuret of iron. (*SCHAEFFER*.)—In *New York*, at Farmington, the water of Clifton springs deposits Sulphur in grains. Moss and other vegetables, over which the water flows, become incrustated with Sulphur. (*MITCHILL*.)—Also near West Point, it occurs pulverulent, and grayish, in the cavities of a ferruginous, granitic rock. (*DOUGLASS*.)

(*Mode of obtaining Sulphur*.) The Sulphur, employed in commerce, is in part collected in those places, where it occurs native, as in the Solfaterra, Iceland, Sicily, &c.; but is chiefly extracted from pyrites, or the sulphuret of iron or of copper. Different processes are employed. Sometimes pyrites and wood are arranged in alternate layers in the form of a large, truncated, quadrangular pyramid. The roasting is continued for several months, the Sulphur itself supporting the combustion, after the wood is consumed. During this process, the Sulphur sublimes, and is condensed and collected in hollows in the upper part of the pyramid, whence it is removed several times in a day.

In other cases, the pyrites is reduced to a coarse powder, and placed in earthen tubes of a conical form, or in iron retorts, where the Sulphur is disengaged and melted, and thence runs into vessels of water. It is thus obtained in Saxony; and 900 pounds of pyrites yield from 100 to 150 pounds of crude Sulphur, which is further purified by distillation, by which it loses about one eighth of its weight.—It is then melted and cast in wooden moulds into cylinders, known in commerce by the name of sulphur or *roll-brimstone*.—When further purified by sublimation, it is called *sublimed Sulphur* or *flowers of Sulphur*.

The uses of Sulphur in chemistry, medicine, and the arts are numerous, important, and sufficiently well known.

SPECIES 3. BITUMEN. HAUSMANN.

Bitume. *Hauy*. *Brongniart*. Black mineral Resin. *Jameson*.

Bitumen, especially when a little heated, may be recognised by its peculiar odor, which to many persons is not unpleasant. Some varieties are liquid, others soft, and others too hard to receive an impression from the finger nail, but, at the same time, very brittle. The liquid and softer varieties yield more or less odor, even when cold.

The specific gravity of Bitumen is often below 1.00, and never exceeds 1.20, unless the specimen be impure. By friction it acquires

negative electricity. When liquid, it is sometimes yellowish or brownish, and sometimes limpid and transparent; but the more solid varieties are black or brown.

It burns easily, yielding a thick smoke, which has a strong, peculiar odor, but not very pungent. There is sometimes a very small earthy residuum after combustion. The solid varieties are easily melted, but, when cool, they are very brittle. Bitumen yields little or no ammonia by distillation. Its principal ingredients are hydrogen and carbon. It is insoluble in water and alcohol, but combines with fixed and essential oils. (*MURRAY.*)

Bitumen presents several varieties, most of which evidently pass into each other, proceeding from Naphtha, the most fluid, to Petroleum, which is less fluid, thence to Maltha, which is more or less cohesive, and thence to Asphaltum, which is solid. Hence the characters of some specimens are intermediate between two varieties.

Var. 1. NAPHTHA. KIRWAN. JAMESON.* This variety is fluid and transparent, a little unctuous to the touch, and constantly exhales a strong bituminous odor. Its colors are grayish or yellowish white, sometimes wine yellow, or with a tinge of green. It swims on water, and its specific gravity varies from 0.71 to 0.84.

It takes fire even on the approach of a lighted taper, and burns with a bluish flame, yielding a thick smoke, and leaving no residue. When perfectly pure, its odor is feeble; it burns with a white flame, and undergoes no change by exposure to the atmosphere. But, when contaminated with petroleum, it absorbs oxygen, and acquires color. It contains, according to Saussure, carbon 87.2, hydrogen 12.8.

This is the rarest variety of Bitumen, and is seldom found perfectly pure.

(*Localities.*) One of its most remarkable localities is in Persia, near Baku, on the western shore of the Caspian Sea. The soil is here sandy and marly, and the surrounding minerals are calcareous. The Naphtha is constantly rising in the state of an odorous, inflammable vapor; hence, by inflaming this vapor, the inhabitants obtain a perpetual fire, which, being concentrated in earthen tubes, is employed for preparing food, &c. The Naphtha is here collected at the bottom of pits, which are dug in the surrounding soil to the depth of several yards. It is yellowish, not perfectly limpid, and requires distillation.—It is found also on Mount Zibio, near Modena, &c. In 1802, near Amiano, in the Dutchy of Parma, a spring was discovered, yielding a yellowish Naphtha very abundantly. Its specific gravity is 0.84. It is employed, instead of oil, to illuminate the streets of Genoa.—It is found also in Sicily, &c.

* Variety of Erdol. *Werner.* Le Naphte. *Brochant.* Bitume Naphte. *Brongniart.* Bitume liquide blanchatre. *Hauy.* Naphtha. *Hausmann.* *Aikin.* *Phillips.*

Naphtha is employed in Persia, &c. instead of oil in lamps. It sometimes enters into the composition of certain varnishes.

2. PETROLEUM.* *AIKIN. PHILLIPS.* This Bitumen is evidently an altered or impure Naphtha; it is less fluid and less transparent; it has sometimes an oily consistence or is almost viscid. It is unctuous to the touch, and exhales a strong and rather unpleasant bituminous odor. Its specific gravity sometimes reaches 0.87. It is translucent or almost opaque. Its colors are blackish brown of various shades, reddish brown, brownish yellow, and sometimes greenish yellow.

It burns easily, but less so than naphtha, and exhales a very dense, black smoke, leaving a small earthy residue. By distillation it yields a liquid resembling naphtha, and the remainder has the consistence of pitch and tar.

(*Geological situation and Localities.*) This variety is much more abundant, than the preceding. It is found in secondary rocks, more particularly in the vicinity of beds of coal, in the midst of which or of the accompanying minerals it has sometimes been seen to trickle. It is often found floating on the water of certain springs; and sometimes communicates an irised appearance to water, standing in bogs. Near the base of Mount Vesuvius, it has been seen rising in a spring from the bottom of the sea. (*BRIESLAK.*)—At Gabian, in France, Petroleum runs from the earth with a stream of water, on which it floats, and is collected for commerce.—At Beckelbronn, near Weissemburg, it is mixed with sand in the proportion of about ten per cent. Boiling water extracts from this sand a glutinous bitumen, like maltha, from which Petroleum is obtained by distillation.—In Italy, at Amiano, twelve leagues from Parma, it is extracted from a compact, greenish clay by digging deep pits in the form of an inverted cone; the Petroleum collects at the bottom of these pits, and is drawn up in pails.—At Mount Zibio, near Modena, it swims on the surface of certain springs of water, situated at the bottom of a valley; the surrounding soil is composed of a friable rock, mixed with clay, limestone, and sand, and disengages large quantities of hydrogen gas. In Transylvania, it occurs in most of the salt mines.—In the kingdom of Ava, near Rain-anghong, it is explored by digging deep pits in a hill containing coal; in this hill are about 500 wells, which yield annually 400,000 hogsheads of Petroleum. (*PHILLIPS.*)

In the *United States*, there are numerous localities of Petroleum, of which we select a few. In *Virginia*, on the Kenhawa.—In *Kentucky*, Allen County, 5 miles from Scottsville, on a spring of water; it is sufficiently liquid to burn in a lamp, is collected in considerable

* Erdol. *Werner.* Mineral Oil. *Jameson.* Petrol. *Kirwan.* Bitume Pétrole. *Brongniart.* Le Pétrole, *Brochant.* Bitume liquide brun et noirâtre. *Hauy.* Flussiges Bergtheer. *Ilgusmann.*

quantities, and sells at 25 cents a gallon. (*JESSUP.*)—In *Pennsylvania*, in the western parts of the state.—In *Ohio*, in the north part of Medina County—on Duck Creek, in Monroe County, about 30 miles from Marietta, and in various other parts of the state. (*ATWATER.*)—In Liverpool, a salt well, while boring, yielded about half a barrel of Petroleum daily. (*COIT.*)—In *New York*, at Seneca Lake, &c.—It usually floats on the surface of springs, which, in many cases, are known to be in the vicinity of coal. It is sometimes called Seneca or Genessee oil.

(*Uses.*) When purified, it is sometimes burnt in lamps. Sometimes also it is employed instead of tar; and in some places is used by external application, as a remedy for rheumatism, chilblains, &c.

Petroleum, by exposure to the air, acquires a greater degree of consistence, and passes into the following variety.

3. MALTHA.* This is still less fluid, than the preceding variety; it is viscid and tenacious, like pitch, and sometimes almost solid, especially when the weather is cold. It is unctuous to the touch, exhales a bituminous odor more or less strong, and has a resinous lustre. It is heavier than Petroleum, but usually swims on water. Its color is black, brownish black, or reddish brown.

When burnt, it yields more smoke and soot than Petroleum, and leaves a greater residue.

(*Localities.*) It is found in nearly the same places as Petroleum; and by exposure to the air is said to pass into Asphaltum. Near Clermont in France, it is mingled with the soil, and attaches itself to the feet of those, who walk over it.

(*Uses.*) It is sometimes employed for the same purposes as tar or pitch on cables, in calking vessels, &c. It enters into the composition of varnishes, designed to protect iron from rust, and sometimes forms an ingredient in black sealing wax. The ancients are said to have employed it as a cement in the construction of walls and buildings.

4. ELASTIC BITUMEN.† *HATCHETT. PHILLIPS.* This variety seems to be intermediate between the softer and harder Bitumens. It sometimes much resembles caoutchouc, or India rubber, in its softness, flexibility, and elasticity; and, like that, it removes the traces of plumbago, but, at the same time, soils the paper a little.

Sometimes, however, it possesses but little elasticity, being merely soft; sometimes it is almost dry, and cracked at the surface, and

* Variety of Erdol. *Werner.* Variety of Mineral oil. *Jameson.* Bitume Maltha. *Brongniart.* Bitume glutineux. *Haüy.* Le Goudron mineral, *Brochant.* Mineral Tar. *Kirwan.*

† Elastiches Erdpech. *Werner.* Elastic Mineral Pitch. *Jameson.* Aikin. Bitume elastique. *Haüy.* *Brongniart.* Mineral Cahoutchou. *Kirwan.* La Poix minerale elastique, *Brochant.* Dichter Elaterit. *Hausmann.*

sometimes it has a spongy or corky texture. Indeed the same specimen is sometimes in part elastic, and in part dry. Its lustre is somewhat resinous.—Its color is brown of different shades, reddish or blackish brown, or hyacinth red, and has sometimes a tinge of green or yellow. It is translucent at the edges. The softer varieties yield a bituminous odor. Its specific gravity extends from 0.90 to 1.23.

It burns with a bright flame and bituminous odor, and contains five or six per cent. of foreign matter.

(*Localities.*) This Bitumen has been found almost exclusively near Castleton in Derbyshire. It occurs in nodules in veins of sulphuret of lead, traversing compact limestone, &c. and is accompanied by quartz, calcareous spar, fluat of lime, asphaltum, &c.—A substance, much resembling elastic Bitumen, both in external characters and composition, has been brought from South America by Humboldt.

5. ASPHALTUM.* *KIRWAN*. This Bitumen is dry and solid, and usually very brittle, but often too hard to receive an impression from the finger nail. It is sometimes in small globules. Its fracture is more or less conchoidal, and shining with a resinous lustre; but sometimes it is *earthy*† or uneven, and nearly dull. The earthy variety is less hard, than the others, and seems to be intermediate between Maltha and the harder kinds of Asphaltum.

It is opaque or slightly translucent at the edges; and its color is black or brownish black, sometimes blackish brown, or with a tinge of red or gray. It has little or no odor, unless rubbed or heated. Its specific gravity extends from 1.04 to 1.60.

It burns freely, and leaves but little residue, unless the specimen be impure. It often contains a little Petroleum. (*HATCHETT.*)

(*Localities.*) In Judea it is found on the shore, or floating on the waters of the Salt or Dead Sea, sometimes called lake Asphaltites. This Asphaltum, also called *Jew's pitch*, is probably fluid, when it rises to the surface of the water, and there becomes solid. It diffuses through the air a disagreeable odor.—In the island of Trinidad is the celebrated Pitch Lake about 3 miles in circumference. Its surface is covered with Asphaltum, which is traversed by numerous and sometimes very deep crevices, filled with good water, which the inhabitants use, and in which mullet and other fish are caught. When visited by Dr. Nugent, the surface of this lake had the color of ashes, and did not adhere to the foot, from which, however, it received a partial impres-

* Schlackiges Erdpech. *Werner*. Slaggy Mineral Pitch. *Jameson*. Bitume solide. *Hauy*. Bitume Asphalte. *Brongniart*. La Poix minerale scoriacée. *Brochant*. Compact mineral Pitch. *Aikin*. Compact Bitumen. *Phillips*. Schlackiges Bergpech. *Hausmann*.

† Erdiges Erdpech. *Werner*. Earthy Mineral Pitch. *Jameson*.

sion, but not so as to render it dangerous to walk upon it. In other seasons of the year, this Bitumen must be much softer, for pieces of unaltered wood were enveloped in it. This Asphaltum is sometimes black and hard with a dull conchoidal fracture; but, in general, it may be easily cut, and its interior appears oily and vesicular. In the candle it melts like sealing wax, and burns with flame, which soon ceases, when removed. When mixed with oil, tallow, or tar, it acquires fluidity, and is used as pitch. In one part of the lake is found Petroleum perfectly fluid. (*NUGENT.*)—It occurs also in Barbadoes; and at Cape St. Antonio in the island of Cuba.—Asphaltum is found in veins at Kamsdorf in Saxony, with calcareous spar, &c. and in Cornwall with the sulphurets of lead, copper, &c.—Near Syrsan, on the Wolga, it occurs in veins or globules in compact limestone.—The earthy variety is found in veins, which traverse graywacke in the Harz, and transition greenstone at Prague. (*JAMESON.*)

(*Uses.*) The ancients appear to have employed both Maltha and melted Asphaltum as a cement in the construction of buildings, &c. Thus the bricks, of which the walls of Babylon were constructed, were cemented by a Bitumen, which was found abundantly in that vicinity on springs, or floating on the river Is, which falls into the Euphrates. Asphaltum or Maltha, either pure, or mixed with a liquid, extracted from the cedar, was employed by the Egyptians in embalming dead bodies.—It is said to protect the bottom of ships in a considerable degree from the attack of the Teredo.

(*Geological remarks.*) It appears that Bitumen, though sometimes in veins, traversing primitive or transition rocks, is found most frequently in secondary rocks or earths, and chiefly in those, which are calcareous or argillaceous. Other minerals, as limestone and shale, are often impregnated with Bitumen. The black limestone of Seefeld in the Tyrol yields by distillation 40 or 50 per cent. of Petroleum.—Pyrites is sometimes impregnated with Petroleum.—It has been remarked, that those countries, which yield Bitumen most abundantly, usually contain mines or springs of muriate of soda.

It is generally believed, that Bitumen has proceeded from the destruction of vegetables and animals in the interior of the earth.

Naphtha and Petroleum may very probably arise from the decomposition of coal, effected by subterraneous fires, either volcanic, or produced by the combustion of coal, or the decomposition of pyrites; and these fluid Bitumens, by exposure to the air, may gradually pass into a state more or less solid.

APPENDIX TO BITUMEN.

1. RETINASPHALTUM. *HATCHETT.*Retinasphalt. *Aikin. Phillips.* Retinite. *Jameson.*

Its color is brownish yellow of different shades, sometimes yellowish or dark brown, or with a shade of red. It is more or less translucent, or opaque. It occurs in crusts or small masses, which have an imperfectly conchoidal or uneven fracture, with a resinous lustre somewhat shining. It is soft and brittle; but, when recently taken from the earth, is often flexible and elastic. Its specific gravity is 1.13.

On hot iron it melts, smokes, and burns with a bright flame, exhaling a fragrant odor, which at last becomes bituminous. It yielded Hatchett resin 55, asphaltum 42, earth 3.

In Devonshire, at Bovey Tracy, it adheres to brown coal or Lignite.—In Staffordshire, at Rowley, &c. it occurs in a coal formation, forming layers about $\frac{1}{16}$ of an inch thick within the coal. (*FINCH.*)—A similar mineral has been found in Saxony, Moravia, and Austria.

2. FOSSIL COPAL. *JAMESON.*Fossil Copal. *Aikin. Phillips.* Highgate Resin.

It occurs in pale yellowish brown, irregular masses of moderate size, more or less translucent. It is brittle; yields with ease to the knife; and has a resinous lustre. Its specific gravity is 1.05.

When heated, it exhales a resinous, aromatic odor, and melts into a limpid fluid. In the flame of a candle, it takes fire, and burns with a clear yellowish flame. Before the blowpipe, it leaves no perceptible residue.

It was first found at Highgate Hill, near London, in a bed of blue clay.—It occurs also in New Spain, in the district of Jutacan. (*MITCHILL.*)

3. HATCHETINE. *CONRBEARE.*

The color of this recently discovered substance varies from yellowish white to wax or greenish yellow. It is somewhat translucent, or opaque. It is destitute of odor, and has about the hardness of soft tallow. It has sometimes a flaky texture, like that of spermaceti, with a glistening pearly lustre, and sometimes it is dull with a texture like that of bee's wax.

It melts in water heated to 170°; and is soluble in ether.

It has been found in South Wales, at Mezthyr Tydfil, with calcareous spar and quartz, in a vein, traversing ironstone. (*CONRBEARE.*)

SPECIES 4. AMBER. KIRWAN. JAMESON.

Bernstein. Werner. Hausmann. Succin. Haüy. Brochant. Brongniart. Amber. Aikin. Phillips.

The claims of this substance to the characters of a mineral are, like those of many other combustibles, of a secondary nature.

Its color usually presents some shade or tinge of yellow, but varies from yellowish white* to wax or honey yellow,† sometimes intermixed with gray or brown; it also occurs reddish brown, hyacinth red, reddish yellow, and even greenish white, or dark brown. It is translucent, though sometimes very feebly, or is even opaque, and sometimes it is transparent. It easily yields to the knife, but is sufficiently compact and hard to be turned and polished. By friction it easily acquires negative electricity. When pure, its specific gravity is about 1.08.

It occurs in grains, nodules, or small irregular masses, and sometimes in stalactites. It has usually a compact texture, and a conchoidal fracture, which is sometimes imperfect. Its lustre is splendid or only glistening, and more or less resinous. The earthy variety is dull.—Some varieties have a slaty structure.

(*Chemical characters.*) It burns with flame and smoke, and with a little intumescence, but does not become very liquid, if the heat be moderate. It exhales, while burning, an agreeable odor, and leaves but little residue. It is not easily soluble in oils, unless gently roasted. By distillation an empyreumatic oil, and the succinic acid are obtained from Amber.

(*Distinctive characters.*) Amber is distinguished by its partial fusibility and less specific gravity from the mellate of alumine.—It sometimes perfectly resembles copal in its external characters, but, according to Haüy, may be distinguished by the following experiment. If a fragment of Amber, attached to the point of a knife, be inflamed, it burns with some noise and a kind of ebullition, but without becoming so liquid as to flow, and, if it falls on the table, it rebounds a little; whereas a fragment of copal, in similar circumstances, melts and falls in drops, which become flattened.

Var. 1. EARTHY AMBER.‡ JAMESON. It has a dull, earthy aspect, and is more or less friable. Its color is usually yellowish gray, or pale yellowish brown.

(*Geological situation.*) Amber appears to have been hitherto found only in alluvial deposits of sand, clay, gravel, &c. or in rocks of recent formation. It generally occurs in small, detached masses, and is most frequently connected with bituminous wood, brittle lignite, or jet, and sometimes adheres to these substances, or even penetrates them. According to some mineralogists, it has also been observed in coal, coarse

* Weisser Bernstein. Werner. White Amber. Jameson.

† Gelber Bernstein. Werner. Yellow Amber. Jameson. ‡ Bernerde. Werner.

sandstone, and compact limestone.—It is sometimes found floating on the sea, or deposited on the shore by its waves. It is often associated with pyrites.

Flies, ants, and other insects, and small portions of vegetables or of pyrites are sometimes embraced in Amber. These insects, however, are sometimes introduced by dealers in Amber to increase the value of the specimen.

(*Localities.*) This combustible exists in many places, but is seldom abundant. It is obtained chiefly from Prussia, on the shores of the Baltic, and particularly from near Koningsberg, where it is explored by digging through banks of sand, and of clay mixed with rolled pebbles, beneath which lies a thick bed of bituminous wood, impregnated with pyrites. The Amber is found in small horizontal veins in the interior of the wood, or in stalactites attached to its surface, or in scattered masses, or underneath the wood.—It is found also in the sandy parts of Poland, even at a great distance from the sea, and sometimes mixed with the products of the fir.—At Coboalles, in Asturia, it occurs in coal, and has a slaty structure.—In Sicily, it presents various shades of color, and degrees of transparency.—In France, at Auteuil, near Paris, it occurs with lignite, accompanied by mellite.

In the *United States*. In *Maryland*, Ann-Arundel County, at Cape Sable, near Magothy river. It varies from opaque to transparent; and its color, sometimes wax, honey, or reddish yellow, also exhibits various shades, resulting from a mixture of yellow, gray, and brown. Its specific gravity varies from 1.07 to 1.18, in consequence probably of intermixed pyrites. It occurs in grains or masses, sometimes 4 or 5 inches in diameter, usually invested by a rough, grayish crust. It is found, associated with pyrites, in a bed of lignite 3 or 4 feet thick, covered by a stratum of sand, which at the lower part is converted into a coarse, ferruginous sandstone. At the same place is found the earthy variety in small, friable masses, of a dull yellowish gray color. Underneath the lignite, which contains the Amber, is found sand and earthy lignite, abounding with pyrites. (*TROOST.*)—In *New Jersey*, on Crosswick's Creek, 4 miles from Trenton, it occurs in alluvial soil. The Amber is both yellow and whitish, and occurs in grains or small masses, seldom exceeding an inch in length; it rests on lignite or carbonated wood, or even penetrates it, and is sometimes connected with pyrites. The stratum of lignite, which contains the Amber, rests on a coarse, ferruginous sand, and is covered by a soft bluish clay, embracing masses of pyrites. Above the clay is a bed of sand. (*WISTER. CONRAD.*)—Amber exists also near Woodbury, in the same State, in large plates in a bed of marl; also at Camden, opposite Philadelphia, where a transparent specimen, almost white, and several

inches in diameter, has been found in a stratum of gravel. (*WOOD-BRIDGE.*)

(*Remarks and Uses.*) Most naturalists are induced to believe, that Amber is a resinous juice, which once proceeded from certain trees, but has since been gradually mineralized in the interior of the earth. It occurs in masses, whose weight usually varies from some fraction of an ounce to a few pounds; and its largest masses, which are extremely rare, do not much exceed 20 pounds. The largest mass perhaps ever seen was recently found between Memel and Königsberg, measuring 14 inches in length by $9\frac{1}{4}$ in breadth, and weighing 21 pounds.

The ancients were acquainted with Amber; and Thales, 600 years before Christ, knew that it could be rendered electric by friction; indeed the term *electricity* is derived from the Greek word, *ηλεκτρος*, signifying *Amber*.

It is susceptible of a good polish, and is wrought into various ornamental articles. It was much esteemed by the ancients, and is now more highly valued by Asiatics than by Europeans.—It is employed in the composition of certain varnishes; of this kind is the lacquer varnish, applied to philosophical instruments of brass or copper.—The oil and acid of Amber have been used in medicine.—Jet is sometimes sold under the name of *black Amber*.

SPECIES 5. DIAMOND. KIRWAN.

Demant. Werner. Hausmann. Diamant. Hauy. Brochant. Brongniart. Octahedral Diamond. Jameson. Diamod. Aikin. Phillips. Adamas. Pliny.

The most essential character of the Diamond is its extreme hardness, by which it is enabled to scratch the corundum and all other minerals without exception. It is usually more or less transparent, but seldom attains that perfect transparency, which crystallized quartz often exhibits; one variety is nearly opaque.—Its refraction is simple, but very great in proportion to its density, when compared with incombustibles. Whether rough or polished, it acquires positive electricity by friction.

Although so extremely hard, it is easily broken in the direction of its laminae, presenting a foliated fracture; or rather it yields to mechanical division in four directions, parallel to the sides of a regular octaedron, which is its primitive form. Its external lustre is variable, but its internal lustre is splendid, and of that peculiar kind, called adamantine; sometimes also it is resinous.

The Diamond is without doubt always the result of crystallization, although its crystalline form is often imperfect, or entirely disappears. It sometimes presents its primitive octaedron, either perfect, or trun-

eated on the solid angles, or on the edges.—It also occurs in cubes, or in dodecaedrons with rhombic faces. Its general aspect is often spheroidal, arising from the convexity of its faces, and the obtuseness of its edges. One of its secondary forms presents forty eight curvilinear faces (Pl. IV, fig. 34.); in this crystal each face of the primitive octaedron is divided into six smaller faces, separated from each other by six edges, which proceed from the centre of the primitive face, three of them to its angles, and three to the middle of its sides; or each solid angle of the octaedron is replaced by eight faces.—Sometimes its crystals present twenty four faces.—In fine, the primitive octaedron is so altered in appearance, that its secondary forms are sometimes described as three-sided pyramids, either single or double, or as double six-sided pyramids.

The faces of the crystals are frequently convex, and the edges a little curved. Sometimes the faces parallel to those of the primitive form are plane, while the others are convex. All these spheroidal modifications seem to result from a tendency in its crystallization to a regular solid with forty eight faces. The crystals are usually small. The integrant particles are regular tetraedrons.

The Diamond also occurs in cylindrical masses, or in small, amorphous grains.

The Diamond is usually limpid, or presents some shade of gray or white, sometimes tinged with yellow, blue, or green; it also exhibits certain shades of green, yellow, orange, red, blue, or brown. Its specific gravity extends from 3.40 to 3.60.

It is sometimes phosphorescent in the dark, after exposure to the sun's rays, especially the blue rays of the solar spectrum.

(*Chemical characters.*) The Diamond is combustible without any sensible residue; and begins to burn, according to Mackenzie, at 14° W. Newton observed the strong refractive power of the Diamond in proportion to its density, and suggested that it was a combustible. But its combustibility appears to have been first established by experiment in 1694, in the presence of the Grand Duke of Tuscany. Lavoisier ascertained, that, during its combustion in oxygen gas, it yielded carbonic acid; and the subsequent experiments of Tennant, Guyton, Allen and Pepys seem to have proved, that the Diamond is composed of *pure carbon*. Like carbon, it unites with iron, and converts it into steel.

M. Biot has recently made some ingenious calculations on the refractive power of carbon, as it exists in carbonic acid, and finds it to be very small; he hence infers, that the Diamond cannot be composed of pure carbon, but must contain about one fourth its weight of hydrogen, from which it derives its great refractive power. We ought,

however, cautiously to admit mere calculation in opposition to chemical experiments, especially as, in this case, it does not appear perfectly obvious, that *carbon* in carbonic acid must have the same refractive power, as *carbon crystallized* in the Diamond.

(*Geological situation and Localities.*) The geological characters of the Diamond are but little known. It is often found in alluvial earths; and is most commonly scattered in sand or gravel, which is often very ferruginous, containing clay and rolled pebbles.—It is also found in a kind of puddingstone, or ferruginous sandstone, containing pebbles of quartz.—Sometimes the Diamonds occur immediately under the vegetable earth, or even in loam; and sometimes under a kind of sandstone. They also occur in sand, which has been deposited by rivers; and have, without doubt, in all cases, been transported from the mountains, not far from the foot of which they are found.

India, Brazil, and the island of Borneo are almost the only countries, which furnish the Diamond. In India, it is found from Cape Cormorin to Bengal, but chiefly in the provinces of Golconda and Visapour, and at the foot of the Orixia mountains in Bengal. The mines at present most esteemed, and which have furnished the most famous Diamonds, are near the junction of the Kista and Krishna rivers.—In Brazil, the Diamond is found chiefly in the District of Cerro do Frio, in Minaes Geraes. One of the predominant rocks of this country is a sandstone, containing numerous pebbles of quartz. The Diamonds occur principally in a deposit of pebbles, gravel, and ferruginous sand, there called *cascalhō*. The principal mine is on the river Jigitonhonha, whose course is occasionally diverted, for the sake of exploring the *cascalhō* in its bed. The low grounds, on each side of the river, are also rich in Diamonds. (*MAWE.*) The *cascalhō* is sometimes indurated and very ferruginous, containing Diamonds in cavities, lined with minute pallets of gold.

Both in Brazil and India, the sand or *cascalhō* is washed for the purpose of bringing the Diamonds to view.

(*Remarks and Uses.*) Diamonds can be cut and polished only by friction against each other, or rather by means of their own powder. They are sometimes sawed by a delicate iron wire, coated with the powder of the Diamond. This art was unknown till about the year 1476; and of course the ancients could not have been acquainted with the great brilliancy of the Diamond, as this in so great a degree depends on the art of the lapidary.

The peculiar lustre and play of colors, which the Diamond presents, arise from the great quantity of light, which is reflected; and this copious reflection results not only from the great refraction and dilatation of the rays of light during their passage through this transparent

combustible, but also from the inclination of the faces.—According to Newton, the refractive power of the Diamond is to that of quartz nearly as 8 to 3, whereas the density of the former is to that of the latter as 4 to 3.

Its name is derived from the Greek *αδαμας*, *invincible*, in allusion to its extreme hardness.

The *uses* of the Diamond, as a gem, are well known. It is also employed for cutting glass—for wheel pivots in watches—and to furnish powder for polishing other Diamonds, &c.

The Diamonds, selected for cutting glass, are crystals, which present curved faces, bounded by curvilinear edges. When used, the Diamond should be so held, that the surface of the glass may be a tangent to the curved edge, near its extremity, the two lateral faces, which form this edge, being equally inclined to the glass.

Diamonds, when cut and polished, are divided by jewellers into *brilliant*, *rose*, and *table* Diamonds, differing from each other in the number, form, and inclination of the faces. When a Diamond is pure and transparent, it is said to be of the *first water*.

The weight of the Diamond is expressed in *carats*, and the carat is divided into four grains. According to Jameson, the average price of a rough Diamond, which can be employed as a gem, is about £ 2 for the first carat; but its value increases in a much greater ratio than its weight. Thus the value of a wrought Diamond, of one carat in weight, is £ 8—of two carats, £ 32—of ten carats, £ 800—of twenty carats, £ 3,200—and of fifty carats £ 20,000.

The mines of Brazil, at present, furnish Europe with more Diamonds than those of India and Borneo.

Very large Diamonds are extremely rare. There is one in the possession of the Rajah of Mattan, in Borneo, which weighs 367 carats. The Rajah has refused \$ 150,000 and two large war brigs, offered for this Diamond by the Governor of Batavia.—The Diamond on the top of the sceptre of the Emperor of Russia is about the size of a pigeon's egg, weighs 195 carats, and was formerly one of the eyes of a Brahminical idol. The Empress Catharine paid for this gem about \$ 416,000, and an annuity of about \$ 16,000.—The Pitt or Regent Diamond, weighing about 137 carats, cost £ 130,000, and now adorns the handle of the sword of state of the King of France.

It is remarked by Haüy, with his usual elegance, that the Diamond, though in most cases *colorless* itself, is still capable of dazzling the eye by its brilliant and playful *colors*, constantly fugitive, but perpetually returning.

SPECIES 6. ANTHRACITE. HAUY. BRONGNIART.

Glanzkohle. *Werner.* Glance-coal. *Jameson.* Native Mineral Carbon. *Kirwan.* Blind Coal. *Aikin.*
 Anthrazit. *Hausmann.* Anthracite. *Phillips.*

This combustible, at first view, strongly resembles coal, from which, however, it materially differs. Its color is black, or rather grayish or iron black, sometimes tinged with blue or brown, and sometimes passing to blackish or steel gray. It very rarely, if ever, possesses the pure, deep black of coal. It sometimes presents irised or tarnished colors. It is perfectly opaque.

The Anthracite is harder than the common slaty coal, but is at the same time very easily frangible. It usually soils the fingers more or less, and leaves on paper a dull, black trace. It is not unctuous to the touch. It is heavier than coal, its specific gravity usually lying between 1.40 and 1.80; and it is a conductor of electricity.

Its texture, sometimes granular or compact, is more frequently slaty. Its fracture is more or less conchoidal with a lustre, either metallic or resinous, often shining, and sometimes splendent.

(*Chemical characters.*) The Anthracite burns slowly and with difficulty, yielding little or no flame, nor smoke, nor any bituminous odor. By combustion it affords carbonic acid, leaving a residue of from two or three to twenty per cent. of grayish ashes. It yields no bitumen by distillation; and the feeble flame, which it sometimes presents, appears to arise from the hydrogen of the water, it contains.—The Anthracite, like the Diamond, appears to be essentially composed of pure carbon, but in a very different state of aggregation; it usually contains also a little silex and alumine, and sometimes oxide of iron. The Anthracite of Kilkenny contains about 97 per cent. of carbon;—that of Rhode Island about 94 or 95. (*MEADE.*) Other varieties contain less.—It is sometimes nearly allied to graphite.

(*Distinctive characters.*) Anthracite may be distinguished from coal by the difficulty, with which it burns, by its greater specific gravity, and by its composition.—From graphite it differs by being less heavy; and its trace on paper is dull and blackish, whereas that of graphite is a shining metallic gray; and further, graphite is unctuous to the touch.

Var. 1. SLATY ANTHRACITE. PHILLIPS.* This is the more common variety. Its structure, and of course its fracture in one direction, is more or less distinctly slaty; and it usually divides into layers, whose surface is uneven or undulated, and sometimes striated. Its cross fracture is more or less conchoidal, or uneven. Sometimes it seems to be composed of brilliant, crystalline laminæ, arranged in

* Anthracite feuilleté. *Haüy. Brongniart.* Schieferige Glanzkohle. *Werner.* Slaty Glance-coal. *Jameson.* La Blende charbonneuse. *Brochant.* Gemeiner Anthrazit. *Hausmann.*

various directions. Indeed the Anthracite has been observed in regular, hexaedral laminæ, and perhaps in acute octaedrons. (*HAUY.*)

2. GRANULAR ANTHRACITE.* It occurs in granular masses, which are friable, and strongly soil the fingers.

3. CONCHOIDAL ANTHRACITE.† Its texture is compact, and its fracture conchoidal, often with a very high metallic lustre. It often breaks into large scales or fragments with undulated or uneven surfaces. It sometimes scarcely soils the fingers.

Anthracite also occurs in small globular masses.

4. COLUMNAR ANTHRACITE.‡ *PHILLIPS.* It occurs in masses, composed of thick, columnar, or prismatic concretions, parallel, but often a little curved. It is very easily frangible, and has an imperfectly conchoidal fracture.—It burns without flame or odor, leaving a residue of whitish ashes. (*JAMESON.*)

(*Geological situation and Localities.*) The Anthracite is sometimes in masses, disseminated in other minerals, sometimes in veins, and sometimes in beds, which usually correspond in their directions and windings to the strata of accompanying minerals.

It most frequently occurs in primitive or transition rocks, as mica slate, argillite, &c. and is sometimes connected with secondary rocks. It is hence obvious, that this combustible has not, at least in many cases, proceeded from the decomposition of vegetable substances, which are not supposed to have existed, when the primitive rocks were formed.—In Spain, it occurs in gneiss.—In the Pyrenees, it is in veins, traversing an argillite, which contains the macle.—Anthracite, crystallized in hexaedral laminæ, has been found in Holland on a granitic rock, which is supposed to have been brought from Norway. (*FLEURIAU DE BELLEVUE.*)—In Dauphiny, it occurs in irregular masses in a pudding or graywacke, composed of fragments of primitive rocks.—Near Allemont in France, at an elevation of more than 2500 yards, it is found between beds of a black slate, which contains vegetable impressions.—At Mount Meissner in Hessa, the conchoidal and columnar varieties, associated with lignite, are found under basalt and greenstone.—The Anthracite of the Alps is by some supposed to belong to transition rocks.—In Scotland, it exists in coal formations. In Ayrshire, near New Cumnock, columnar Anthracite forms a bed from 3 to 6 feet thick, and is associated with graphite, in a coal formation. In Calton Hill, near Edinburgh, it is connected with trap rocks.—In Wales, in

* Anthracite friable. *Brongniart.*

† Anthracite compacte. *Haüy.* Anthracite ecailleux. *Brongniart.* Muschliche Glanzkohle. *Werner.* Conchoidal Glance-coal. *Jameson.* La Houille éclatante. *Brochant.* Massive Anthracite, *Phillips.* Schlackiger Anthrazit. *Hausmann.*

‡ Stangenkohle. *Werner.* Columnar Glance-coal. *Jameson.* La Houille scapiforme. *Brochant.*

Caermarthenshire, &c. and is sometimes called *Welsh culm*.—In Ireland, at Kilkenny; and is sometimes called *Kilkenny coal*.

In the *United States*. In *Arkansas Territory*, on the N. side of the Arkansas river, 500 miles from its mouth, Anthracite, of good quality, forms a large bed. (*BRINGIER*).—In *Pennsylvania*, on the northeastern branch of the Susquehanna, and near the heads of the Lahawanock, Fishing, Muncey, Lehigh, and Schuylkill rivers. It extends down the Susquehanna to about 10 miles below Sunbury, and down the Schuylkill to about 20 miles above Reading. Its extent eastward from the northeastern branch of the Susquehanna is about 30 miles, while it extends but 2 or 3 miles westward from the same branch. It is associated with transition rocks. At Wilkesbarre, the Anthracite appears at the surface, and forms beds from 20 to 30 feet thick. It does not, like the Anthracite of Rhode Island, incline to graphite. Mines are worked at Wilkesbarre, and on the heads of the Lehigh and Schuylkill. At Wilkesbarre, the price is about $12\frac{1}{2}$ cents a bushel. In Philadelphia, it has been sold at from 50 to 60 cents a bushel; but, by improvement in the navigation of the rivers, its price must soon be reduced to 25 or 30 cents. (*COOPER*.) This Anthracite has a strong lustre, and soils the fingers very little. Its specific gravity is 1.61. (*WOODHOUSE*.) In connexion with the Anthracite on the Susquehanna and at Bethlehem is found in thin veins a black, friable substance, having an earthy texture, and soiling the fingers. It appears to be carbon nearly pure, and in a state of minute division. When washed, it is employed as a substitute for lampblack, and is said to be useful in the manufacture of printer's ink. (*WOODBIDGE*).—In *New York*, near Hamilton College, in cavities in quartz; it is black, friable, has an earthy texture, and soils the fingers. (*PIERCE & TORREY*).—In *Rhode Island*, at Portsmouth, &c. The color of this Anthracite is black or grayish black with a metallic lustre; its structure is slaty; and it soils the fingers very considerably. Its specific gravity extends from 1.45 to 1.75. It contains about 94 per cent. of carbon, and is not contaminated with sulphur. This Anthracite, sometimes very near the surface, is covered by argillaceous sandstone and shale, the latter of which exhibits vegetable impressions, and sometimes contains indurated talc and asbestos. The strata are inclined, and belong, according to Dr. Meade, to the independent coal formation.—Anthracite is found also at Providence and Cumberland in the same State. At the latter place, its structure is more slaty than that of Portsmouth, it soils the fingers more, and approaches graphite. (*MEADE*).—In *Massachusetts*, near Worcester, an Anthracite approaching graphite occurs in beds near the surface; it is used as a pigment, &c. (*MEADE*.) In fine, it is the opinion of the mineralogist just mentioned, that Anthracite may be found in many

places on a line extending from Rhode Island through Worcester in Massachusetts to Keene and even Hanover in New Hampshire.

(*Uses.*) When once ignited, it burns with a strong and durable heat; and indeed much of the difficulty of kindling it may be avoided by the addition of a certain quantity of charcoal, and by a strong current of air judiciously managed.

As it is composed almost entirely of carbon without bitumen or even sulphur, except from the accidental presence of pyrites, it burns without caking, and is very useful in those operations, where a durable and uniform degree of heat is required. Hence its use in smelting iron ore, and the preparation of steel; in burning limestone; in salt-works, and other processes of evaporation; in distillation, preparing malt, &c. &c. But, as it burns without flame, it cannot be employed in reverberatory furnaces; and, as it does not cake, it cannot be used by the smith for those purposes of the forge, where a *hollow* fire is required. We have already remarked, that it is sometimes employed as a pigment.

Its name is from the Greek *ανθραξ*, carbon, or coal.

APPENDIX TO ANTHRACITE.

MINERAL CHARCOAL. JAMESON.

Mineralische Holzkohle. *Werner.* Fasriger Anthrazit. *Hausmann.* Mineral charcoal. *Aikin, Phillips.*

This combustible is grayish black, or nearly black. It has a fibrous structure; and a feeble, glistening silken lustre. In some cases, its texture is obviously ligneous. It soils the fingers; and is almost friable. It is heavier than common charcoal.

It burns without flame or smoke, leaving a residue of ashes; and is composed essentially of carbon only.

It is found in small tabular or irregular masses in coal, or lignite; and is sometimes connected with Anthracite. It is not uncommon in coal mines.

SPECIES 7. GRAPHITE. HAUR.

Graphit. *Werner.* Hausmann. Rhomboidal Graphite. *Jameson.* Graphite. *Brongniart. Brochant.* Plumbago. *Kirwan. Aikin. Phillips.* It is very improperly called *Black lead.*

The Graphite is dark steel gray, or nearly iron black. It leaves on paper a well defined, shining trace, which has very nearly the color of the mass, and consists of minute grains. Its name is from the Greek *γραφω*, to write. It is perfectly opaque, easily scraped by a knife, unctuous to the touch, and soils the fingers. It is a conductor of electricity, and, when rubbed on sealing wax, till a metallic trace appears, communicates no electricity to the wax. Its specific gravity varies from 1.98 to 2.26. Its streak is shining and metallic.

Its structure is sometimes foliated, but most commonly granular; it is often also a little slaty. Its fracture is uneven or granular, and often seems to present scales or minute folia; its lustre is metallic, and more or less shining.

(*Chemical characters.*) Before the blowpipe it burns, and slowly consumes without flame, leaving a small residue of oxide of iron. It is composed of carbon with a small quantity of iron. The proportions, according to Bertholet, are carbon 91, iron 9;—according to Saussure, carbon 96, iron 4;—and according to Allen and Pepys, carbon 95, iron 5. It is sometimes contaminated by clay, pyrites, or quartz.

(*Distinctive characters.*) The Graphite and sulphuret of molybdena often strongly resemble each other, and leave on *paper* very similar traces. But, if a fragment of Graphite be rubbed on porcelain or any fine, white ware, its trace preserves its usual color, whereas the sulphuret of molybdena, thus rubbed, leaves a greenish or yellowish green trace. And further, sulphuret of molybdena, rubbed on sealing wax, communicates to it positive electricity.—The color of its trace will serve to distinguish it from graphic slate and anthracite.

*Var. 1. FOLIATED GRAPHITE.** This variety is sometimes in small, rhomboidal or hexagonal laminæ, often flexible, and much resembling the sulphuret of molybdena in color. It also occurs in regular, hexaedrical prisms, sometimes truncated on the terminal edges or solid angles. The laminæ separate in one direction only.

2. GRANULAR GRAPHITE.† It occurs in amorphous masses, or in nodules, which are sometimes very small. The aspect of its fracture varies according to the size of the grains, which are sometimes extremely minute; hence it may appear scaly, or uneven, or may have a very compact texture.

(*Geological situation and Localities.*) The Graphite has in most cases been found in primitive or transition rocks, through which it is sometimes disseminated in laminæ or nodules of various sizes. It also occurs in beds, sometimes considerably large.

In Norway, near Arendal, the foliated variety is found in quartz.—In Greenland, it has been observed in hexaedrical prisms.—In Bavaria, France, Spain, &c. Graphite is also found. But the most celebrated mine is at Borrodale, in Cumberland, England. This bed is situated in a mountain between beds of argillite, traversed by veins of quartz; the Graphite occurs in nodules often considerably large. Its quality is variable, but much of it is both firm and soft.—In Scotland, near

* Graphite cristallisé et lamelliforme. *Hauy*. Graphite lamellaire. *Brongniart*. Schuppiger Graphit. *Werner*. Blattriger Graphit. *Hausmann*. Scaly Graphite. *Jameson*.

† Graphite granuleux. *Brongniart*. Graphite granulaire. *Hauy*. Dichter Graphit. *Werner*. Hausmann. Compact Graphite. *Jameson*.

Cumnock in Ayrshire, it is associated with greenstone and anthracite in a coal formation.

In the *United States*. In *Missouri*, Madison County, near mine La Motte, &c. (*SCHOOLCRAFT*).—In *Virginia*, Campbell County.—In *Pennsylvania*, Bucks County, in considerable quantity. (*CONRAD*.) From this Graphite good pencils have been made at New York.—Also about 4 miles from Bustletown, where it is soft and of good quality, but traversed by veins of quartz. (*COOPER*).—In *New Jersey*, Sussex County, near Sparta and Hamburg, it occurs foliated and very flexible in foliated carbonate of lime. (*PIERCE & TORREY*).—Also in Hunterdon County. (*SCHAEFFER*).—In *New York*, near the city, in a feldspar rock. (*BRUCE*).—It occurs also in the vicinity of New York in hexaedral prisms about four tenths of an inch long, and sometimes truncated on their terminal edges; their gangue is a brownish oxide of iron, embracing hornblende and mica. (*HAUR*).—Also in Ulster and Orange Counties, in carbonate of lime.—At Mount Dunderberg, it occurs both foliated and compact. (*PIERCE & TORREY*).—Also near Lake George in primitive rocks; it is sometimes in very compact masses, weighing 12 pounds. (*GIBBS*).—Also near Lake Champlain, where it is sometimes in rhomboidal or hexaedral laminæ, with mica and carbonate of lime.—Also in the Highlands, 60 miles above New York, with a structure between lamellar and striated. (*SILLIMAN*).—In *Connecticut*, at Cornwall, in considerable quantities in gneiss, &c. (*BRACE*).—Also at Tolland, disseminated in rolled masses of granite and gneiss. (*WEBSTER*).—Also at Sharon, where it strongly resembles molybdena.—Also at Hebron.—In *Massachusetts*, near Worcester? (see Anthracite).—Also between Sturbridge and Holland 2 miles east from Holland meeting House in primitive strata; it was formerly explored. (*EATON*).—In *New Hampshire*, at Chester, in rolled masses, and in veins traversing mica slate—also on the north side of Mount Monadnock, in nodules, having a coarse texture. (*J. F. DANA*).—Also at Sutton, in considerable quantities; it is sometimes soft, compact, and of good quality.—In *Maine*, at Freeport, in a friable granite;—at Brunswick, in limestone, and on the banks of the Androscoggin, in rolled pieces;—at Bath, in granite.—Also at Gorham;—and at Paris.

(*Uses*.) When of good quality, it is manufactured into crayons or pencils, improperly called black lead pencils. The Graphite, sometimes previously boiled in oil, is sawed into thin plates, one edge of which is inserted in a groove in one half of the wooden cylinder or case; the projecting part of the plate is removed by a saw, and the two semi-cylinders united. The powder, produced in this manufacture, and the coarser kinds of Graphite are mixed with a solution of gum

Arabic or with melted sulphur, and formed into pencils of an inferior kind.—The powder of the Graphite is applied to stoves and other articles of iron to preserve them from rust. Mingled with grease, it is employed to diminish the friction of wheel work, &c.—Mixed and kneaded with clay, it is formed into crucibles, which well endure sudden changes of heat.

Excellent pencils have recently been manufactured at New York. The Graphite, obtained from Buck's County, in Pennsylvania, is reduced to powder, formed into a mass by some cement, and then sawed into thin tables, as usual. (*TORREY.*)

Graphite is often artificially formed in iron furnaces.

SPECIES 8. COAL.

Houille. *Hauy.* *Brongniart.* Schwartz Kohle. *Werner.* *Hausmann.* Black Coal. *Jameson.* *Aikin.* *Phillips.* Mineral Carbon, impregnated with bitumen. *Kirwan.*

The external characters of this well known mineral are less important, than its properties as a combustible.

Its color is black, which varies a little in its shade, but is almost always shining; its surface is sometimes very beautifully irised with lively colors. It occurs in opaque masses, whose texture is slaty or compact, and whose fracture is generally even or conchoidal.

It is too hard to be scratched by the finger nail; but it is less hard than carbonate of lime, is easily broken, and is sometimes friable. Its mean specific gravity is about 1.30. (*BRONGNIART.*) It is not electric by friction, unless it be insulated.

(*Chemical characters.*) It burns more or less easily with a whitish flame, yielding a black smoke, and a feeble, but not unpleasant, bituminous odor. The products of this combustion are chiefly carbonic acid and water, and a little sulphurous acid. The residue, which is never less than 3 per cent. and sometimes much greater, is generally composed of scoria often mixed with ashes. By distillation it yields an empyreumatic oil, ammonia, and carburetted hydrogen.—Coal is essentially composed of carbon and bitumen in variable proportions; the carbon however predominates and often constitutes nearly three quarters of the whole. Small portions of earths and oxide of iron are also present.

(*Distinctive characters.*) This mineral is easily distinguished from anthracite, which burns with difficulty, and does not yield the white flame, black smoke, and bituminous odor of Coal.—It is harder than asphaltum, and does not, when slightly heated, exhale a bituminous odor.—The several varieties of lignite, which much resemble Coal, yield by distillation an acid liquor.

The different varieties of Coal pass into each other by insensible shades.

Var. 1. CANNEL COAL. KIRWAN. JAMESON. PHILLIPS.* Its color is black, having usually a slight tinge of gray. Its texture is compact, and its fracture even or conchoidal with large cavities; its lustre is resinous and glistening. It is sufficiently solid and hard to be cut and polished, and is the least brittle variety of Coal. Its specific gravity varies from 1.23 to 1.27.

It contains, according to Kirwan, carbon 75.2, bitumen 21.68, ashes 3.12. A specimen, analyzed by Thomson, yielded carbon 64.7, hydrogen 21.6, nitrogen 13.7. It burns, without softening, with a large bright flame of short duration, leaving a sooty substance; and when the combustion is complete, there is an earthy residue of at least 3 per cent. It does not produce a great heat. Its odor is not unpleasant, like that of jet.—When placed on the fire, it often decrepitates, and breaks into angular fragments.

It is found in England at Wigan and Whitehaven.—Also at Gilmer-ton, &c. in Scotland, where it is sometimes called *Parrot coal*.—The term *Splint* or *Splent* coal has sometimes been given to this variety.

It is sometimes employed, like jet, for making inkholders, toys, &c. Its name, according to Kirwan, is derived from the circumstance of its burning like candles, which in Lancashire are called *cannels*.

2. SLATY COAL.† Its color is black, either pure, or with a slight tinge of gray or brown. It sometimes presents an irised or pavonine tarnish. Its structure is slaty or foliated; and its layers usually divide into prismatic solids, with bases slightly rhomboidal. It is sometimes composed of lamellar distinct concretions. Its cross fracture is even or a little conchoidal, and sometimes uneven; its lustre is resinous, frequently more or less shining, and sometimes even splendid. It is easily frangible; and its specific gravity varies from 1.25 to 1.40.

It burns easily with a bright flame of much longer duration, than that of cannel Coal. It usually swells and agglutinates, or cakes, as it is called, and leaves but little residue, which is more or less a scoria. Several varieties, examined by Kirwan, yielded carbon from 56.8 to 73.5, bitumen from 23.2 to 43.0 and ashes from 1.6 to 5.2. A specimen, analyzed by Thomson, yielded carbon 75.3, hydrogen 4.2, nitrogen 15.9, oxygen 4.6.

This variety usually occurs in the first or independent Coal formation, accompanied by shale, sandstone, &c. It frequently embraces pyrites, and sometimes the remains of marine animals.—It is the more common variety of Coal, employed as fuel, and is found abundantly in many countries.

* Houille compacte. Haüy. Brongniart. La Houille de Kilkenny. Brochant. Kennelkohle. Hausmann. Candle Coal. Aikin.

† Schiefer Kohle. Werner. Hausmann. Slate-Coal. Jameson. Houille feuilletée. Haüy. Variety of Houille grasse. Brongniart. La Houille schisteuse. Brochant.

3. COARSE COAL.* *JAMESON*. This is a little harder and heavier than slaty coal. Its structure is usually somewhat slaty, but its cross fracture is coarse grained uneven. Its color is dark grayish black, and its lustre glistening, and resinous. Its specific gravity is often 1.45.

It burns less easily than the preceding variety, and does not, like that, swell and agglutinate; it also leaves a more abundant residue.

It is sometimes found in compact limestone, and sometimes associated with slaty coal.

4. SOOTY COAL.† Its color is dark grayish black. It is nearly or quite dull, and soils the fingers. It is sometimes pulverulent, and sometimes in light masses, which have an uneven or earthy fracture, and are usually more or less friable.

It burns freely, with a bituminous odor, leaving a small residue of ashes.

It is associated with the slaty variety; and sometimes, as at Stockholm, in Bamberg, it constitutes the whole bed. (*VOIGHT* in Lucas.)

(*Geological situation of Coal.*) The geological characters of Coal are peculiarly interesting; as a knowledge of these may often lead to a discovery of this valuable mineral, when it does not appear at the surface, or assist in exploring its beds.

Coal, though sometimes in irregular masses and rarely in veins, most frequently occurs in beds, having various inclinations and windings. Sometimes the same bed so changes its direction, as to form an acute angle with itself.

The natural associations of coal with other minerals are remarkably uniform, and in general well determined. The varieties of Coal, described under this species, do not occur in primitive rocks, nor in alluvial earths, nor are they often connected even with the most recent formations of secondary rocks; for we do not include under the name of Coal those combustibles, which frequently occur in the preceding situations.

Coal, strictly so called, appears to be of the same age as the older secondary rocks, or immediately to follow them. Thus we find it associated with certain secondary rocks, and resting upon them, or, when these are wanting, it rests on older rocks. Hence a coal formation is sometimes found deposited over limestone, containing fossil remains, and sometimes over primitive rocks.—Sometimes beds of Coal highly inclined are covered by *horizontal* strata of more recent minerals.

Coal has, in a few instances, been observed at a great elevation on the sides of mountains. Thus the Coal mines of Santa Fé de Bogota

* Grob Kohle. *Werner. Hausmann. La Houille grossière. Brochant.*

† Soot-Coal, *Jameson. Russ Kohle. Karsten, Voight. Houille fuligineuse. Haüy.*

in the Cordilleras are elevated more than 4500 yards above the sea. (*BRONGNIART.*) When Coal occurs under plains at a distance from chains of mountains, it is sometimes at a great depth below the surface; as in the vicinity of Namur, where Coal is explored at the depth of nearly 700 yards, and is covered by limestone.

There appears to be several distinct formations of Coal. In the first and most important of these formations, the independent Coal formation of Werner, we find the following minerals, connected with the Coal.

1. A friable sandstone, both micaceous and ferruginous, often very coarse grained, and composed of quartz, with mica and feldspar.
2. Shale or argillaceous slate, which is often micaceous, and sometimes bituminous; it presents impressions of vegetables, particularly of ferns and reeds, and sometimes of fish.
3. Beds of marl, compact limestone, and indurated clay.
4. An argillaceous porphyry, often in thick beds, and embracing roots, branches, and even whole trees petrified.
5. Argillaceous iron ore.
6. A puddingstone, composed of rolled pebbles, cemented by a ferruginous clay or sand.

Of the foregoing rocks the friable micaceous sandstone, the shale, and the puddingstone are the most constantly found with Coal. Prof. Jameson has observed greenstone, amygdaloid, and graphite, connected with the preceding series.

The coal of this formation is almost always deposited in a series of beds, which may vary in number from two to thirty or more, and in thickness from a few inches to 10 or 12 yards, or even more. These beds of Coal alternate with one or more of the rocks, belonging to this formation; and sometimes this alternation appears to be *periodical*, so that several successive beds of Coal are repeated with the same accompanying minerals, and have very nearly the same thickness. This fact may be observed in the Coal mines near Newcastle, England.

Strata of shale are, in a great number of cases, found contiguous to the upper and lower surfaces of these beds of Coal, constituting the *roof* and the *floor* of the bed; and it has been remarked, that the shale, which covers the Coal, is bituminous, while that, which lies underneath it, has imbibed little or no bitumen. Any of the rocks of this formation may, however, constitute the roof or floor of a bed of Coal.

This formation, which is the most common and embraces the best Coal, constitutes hilly rather than mountainous countries. It is sometimes deposited near the foot of mountains, and sometimes in hollows, having the form of a basin or trough, so that the Coal approaches very near the surface at the extremities of its beds.

A second formation of Coal is found in mountains of secondary trap, composed chiefly of basalt, wacke, and greenstone. This Coal usually occurs in extensive, single beds, which are in most cases thick. These

beds of Coal are sometimes intersected by veins of basalt; and the Coal, contiguous to the vein, is incapable of burning with flame, and is sometimes vesicular.—In Auvergne, Mount Meissner in Hessa, &c. the coal of this formation is covered by basalt; and in the Vicentin it also rests on basalt.

A third formation of Coal is sometimes found in extensive beds, embraced in thick and nearly horizontal beds of compact limestone. This limestone, in the vicinity of the Coal, is frequently blackened by the bitumen it contains, while the shells, which it often embraces, retain their whiteness.

Beds of Coal are often intersected by veins of other minerals, more or less inclined to the horizon. These veins are often called *dikes*. Sometimes a small vein traverses only one bed of Coal; and sometimes the vein is large and traverses all the beds, which belong to the formation. The Coal, in the vicinity of these veins, is more irised and friable, less combustible, and often mixed with the stone, which constitutes the vein; sometimes also it is gray, and porous as coke.—These veins are productive of much impediment and expense to the miner; but the evil may be diminished by attending to a few geological facts.

When a stony vein is found traversing a bed of Coal, the first object is to pierce the vein perpendicularly both to its direction and inclination. But, as the bed of Coal and its accompanying strata are generally displaced by the vein, the chief difficulty consists in regaining the bed of Coal at a small distance on the other side of the vein. This displacing or change of the strata by the vein is sometimes called a *shift*.

If all the strata, which lie over the Coal, are known to be different from those, which are underneath, it may easily be determined, when the vein is pierced, whether the Coal is above or below.—But there is another geological fact of more universal application.—It is known, that those beds, which form the *roof* or upper side of the vein, almost always appear to have *slidden down*, and hence are found *lower*, than the same beds on the other side of the vein. Hence, if the miner meet the vein on its roof or upper side, he must, after piercing it, regain the bed of Coal by an *ascending* gallery; and the reverse, if he meet the vein on the other side.

Other difficulties appear in exploring Coal mines. Sometimes the roof and floor so approach each other, that the bed of Coal almost entirely disappears. Sometimes the continuation of the bed is broken; and, when the bed reappears, it is found on the right or left of the original direction.

Coal sometimes contains metallic substances, of which sulphuret of iron is by far the most common. Carbonic acid and carburetted hydro-

gen gases are disengaged in Coal mines, the latter of which produces those dangerous explosions, which so often take place on the approach of a lamp or other flame.

Some varieties of Coal are subject to spontaneous combustion, produced, it is probable, by the decomposition of the pyrites, which they contain. Indeed some coal mines have continued to burn for many years, constituting pseudovolcanoes, and producing important changes in the superincumbent strata.

(*Localities.*) There are but few countries, in which Coal is not found more or less abundantly. It is, however, rare in Italy, Sweden, and Norway.—In France, there are many coal mines. Those, which yield the best Coal, are found in the northern and northeastern parts, and belong to the first or proper Coal formation.

England is remarkable for her Coal mines, which appear chiefly in the northern, western, and central parts. The two principal mines are at the northern extremity, near Newcastle on the eastern, and Whitehaven on the western side of the Island; they both belong to the first formation. The mine at Whitehaven has been explored to the depth of about 400 yards, and is extended about seventeen hundred yards under the sea. In 1812, there were exported from Newcastle 663,151 chaldrons of Coal of 53 cwt. each, and 326,865 chaldrons from Sunderland. (*WINCH.*)—Coal is also abundant in some parts of Scotland.—It is an important circumstance, that many of the Coal mines of England and Scotland are connected with ores of iron.—In Germany also, Coal exists in large quantities. In the Coal mine of St. Giles, near Liege, a series of twenty three beds of Coal, lying one above another, has been actually explored. (*BRONGNIART.*)

In the island of Cape Breton, at Sidney, Coal is found of good quality, and is much used at Halifax and St. John. In New Brunswick, near the head of Cumberland Bay, and at Grand Lake, near the river St. John's. (*THAYER.*)

In the *United States*, Coal has been explored in several districts, and is known to exist in great abundance. We shall enumerate some of the more important localities, at which Coal has been obtained. But the abundance of wood has hitherto prevented the exploring of most of our Coal mines to any considerable depth or extent. In *Missouri*, at Florissant, and on the Osage river. (*SCHOOLCRAFT.*)—In *Tennessee*, near Knoxville.—In *Kentucky*, at Maysville, &c.—In *Illinois*, near Alton.—Also near the junction of Fox river with the Illinois, about 40 miles S. W. from Chicago. (*SCHOOLCRAFT.*)—In *Indiana*.—In *Virginia*, about 14 miles from Richmond. It is uncertain whether this Coal rests directly on granite or is separated from it only by a thin stratum of argillaceous slate, by which also it is

always covered. The beds or strata of Coal have the same inclination as the granite, which is about 45° . At least 25 shafts have been opened at different distances from each other through an extent of from 5 to 70 miles. At Heth's mine, the Coal is 50 feet thick, while at James' river it is only 25 feet. The deepest shaft in Heth's mine is 350 feet; and the strata, which there cover the coal, are sandstone and argillaceous slate, often exhibiting vegetable impressions. Pure charcoal in the form of sticks or logs is frequently associated with the Coal. (*GRAMMER.*)—Also at Wellsburg, Wheeling, &c.—In *Ohio*, in different parts of the State. In some cases, three successive beds of Coal are found, separated from each other by argillaceous slate or shale, bearing vegetable impressions. The coal of the highest bed burns well, agglutinates, and leaves only a small residuum; that of the second bed is coarse, burns with a flame less bright, and leaves a greater residuum; and that of the third bed, though more abundant, is inferior in quality to the two preceding. From Gallipolis to the Falls of the Ohio, it costs about 10 cents a bushel.—Near Zanesville in sandstone are found fossil fish and trees, converted into sandstone. (*ATWATER.*)—In *Pennsylvania*, on the western side of the Susquehanna, extending from near the mouth of the Juniata through all the country watered by the west branch of the Susquehanna and its streams to Pittsburg, and thence down the Ohio and its streams. The Coal of Pennsylvania is said to extend over one third part of the State. At Pittsburg, where it approaches the surface, it is sold at about 6 cents a bushel. (*COOPER.*) According to Maclure, the independent Coal formation extends from the head waters of the Ohio, with some interruptions, to the waters of the Tombigbee.—In *New Jersey*, at the Pracknes Mountain, near Patterson, and in several places near the Passaic, bituminous Coal exists in thin layers, connected with sandstone and shale. (*PIERCE.*)—In *Connecticut*, a Coal formation, commencing at New Haven, crosses Connecticut river at Middletown, and, embracing a width of several miles on each side of the river, extends to some distance above Northampton in *Massachusetts*. Coal has been found at Durham, Middletown, Chatham, Enfield, South Hadley, &c. within the limits of this formation; in several instances it is rich in bitumen, and burns with a free flame. At Suffield, on the banks of the river of the same name, it forms numerous thin veins, traversing argillite and argillaceous sandstone. In Southington it forms thin veins in shale; and in the same town it sometimes occurs in a white gangue of quartz and sulphate of barytes. (*SILLIMAN.*)

The geographical situation of the anthracite of Rhode Island and Massachusetts, in relation to the Coal formation just described, is very

similar to that of the anthracite on the Lehigh, &c. in regard to the Coal formation on the western waters of the Susquehanna.

(*Uses.*) The uses of Coal are numerous and important; but vary according to the quality of the Coal. For those purposes of the forge, which require a *hollow* fire, the slaty Coal must be employed, as this variety generally possesses the property of agglutinating, and thus produces over the iron a kind of arch, which concentrates the heat. But the same property of caking, which depends on its bitumen, disqualifies it for many operations in the arts and in metallurgy. In these cases, it must previously be deprived of its bitumen and sulphur, and thus converted into *Coke*.

The substance called Coke is light, spongy, and of a shining steel gray color. It burns less easily than Coal, but produces a great heat, and does not cake, nor smoke. The preparation of Coke may be conducted in the same manner, as that of charcoal from wood. By this process from 700 to 1100 pounds of Coke are obtained from one ton of Coal; but the volatile products, consisting of bitumen or *Coal tar* and ammonia, are thus lost. For collecting these, a plan has been contrived by Lord Dundonald, and successfully executed. The Coke is prepared in ovens or stoves, almost close; and from 120 tons of Coal are collected about $3\frac{1}{2}$ tons of tar, and a quantity of ammoniacal salt. (*NICHOLSON'S Chem. Dict.*)

Coal has been used with success in baking stone ware; and Coke is sometimes employed for baking hard porcelain.—When it contains any considerable quantity of pyrites, it is rendered more or less unfit for use, in consequence of the sulphurous acid, produced during its combustion. Sometimes also the heat, liberated by the decomposition of the pyrites, is sufficient to inflame the Coal; and hence the spontaneous combustion of many Coal mines;—such Coal is also easily disintegrated.

According to the experiments of Kirwan, the quantity of carbon in Coal may be ascertained with sufficient accuracy for common purposes by detonation with nitre, which is supposed to consume the carbon, while it acts very little on the bitumen;—and, if the quantity of ashes be ascertained by combustion, the proportion of bitumen may be inferred. (See Kirwan's Min. vol. ii.) Different varieties of Coal produce different degrees of heat.

(*Origin of Coal.*) Most geologists are induced to believe, that Coal has originated from the decomposition of vegetable substances in the interior of the earth. And this opinion seems to be supported by the remains of vegetables, which accompany coal, and by the products, which chemistry obtains, and which are chiefly carbon and hydrogen.

It has however been objected, that vegetables scarcely decomposed are sometimes found in beds of Coal.*

But it appears to be certain, that Coal has been formed subsequently to the existence of organized bodies ; and that, previously to its production, its particles must have existed in a liquid or minutely divided state, whether the solvent were water, or caloric acting under a partial compression. Hence its structure is sometimes almost crystalline ;—hence it is often mingled with portions of contiguous minerals.

The circumstances, under which beds of Coal are found in most countries, and their accompanying minerals, are remarkably uniform. And further, the cause, which has produced the Coal, appears to have been many times repeated ; hence the great number of beds of Coal, which are often found in the *same mine*, under circumstances altogether similar.

The leaves of vegetables, impressed on the shale, which accompanies Coal, are almost always fully expanded, thus indicating a state of rest in the fluid, from which the Coal was deposited.—Jameson, on the authority of Habel, mentions a petrified trunk of a tree, one foot in diameter at one extremity, and forty feet in length, rising through rocks of the Coal formation.—A tree about 30 feet long, with its branches, has been recently observed in the sandstone, connected with the Coal formation near Newcastle, England. The trunk and larger branches are now siliceous, while the smaller branches, bark, and leaves have become Coal. (*WINCH.*)—The small veins of Coal, usually called *Coal pipes*, appear to arise from the conversion of small branches of trees into Coal.

APPENDIX TO COAL.

DYSODILE. *CORDIER.*

Houille papyracée. *Hauy.*

Its color is greenish or yellowish gray. Its masses are composed of thin layers, which have a compact texture, and sometimes very slightly adhere to each other. These layers are tender and brittle ; and, when placed in water, become translucent and flexible. When moistened, it exhales an argillaceous odor. Its specific gravity is 1.15.

While burning, it exhales an odor uncommonly fetid, and leaves a residue, exceeding one third of the weight of the mass.

It is found in Sicily, at Melili, near Syracuse, forming a thin bed in secondary limestone.—Also at Chateauneuf in France, in beds in bituminous marlite.

SPECIES 9. LIGNITE. *BRONGNIART.*

The several varieties, included under this species, exhibit some diversity of external character ; but they have all unquestionably

* Vegetable impressions are rare in strata between beds of Coal.

originated from wood,* which has been buried in the interior of the earth; indeed they frequently exhibit a ligneous texture more or less distinctly. But, although in some varieties this texture may entirely disappear, the Lignite still differs very considerably from Coal.

Most of its varieties burn with flame, but they do not swell nor cake, like coal; the odor, which they exhale, is also sensibly different from that of burning coal or bitumen, and is usually unpleasant, sometimes sharp, or fetid. Like wood, they leave a residue of ashes, but often more abundant. They further differ from coal by yielding, when distilled, a peculiar acid liquor. Their color, sometimes black, is more frequently brown.

The varieties of Lignite are almost invariably found in alluvial earths, or connected with rocks of the most recent formation, as sandstone, shell limestone, or basalt. It is in many cases obviously of more recent formation than coal.—By some, these ligneous substances are viewed as an imperfect coal, as wood not yet mineralized, or passed into the state of coal; while others doubt the transition of Lignite into coal.

Many of its varieties gradually pass into each other.

Var. 1. JET.† KIRWAN. The color of Jet is a pure and deep black, sometimes with a tinge of brown. It occurs in opaque, compact masses, so solid and hard, that they are susceptible of being turned on a lathe and highly polished. Its fracture is conchoidal or undulated, shining or even splendid, and has a resinous lustre. Its specific gravity varies from 1.25 to 1.30. By friction it acquires a weak electricity even when not insulated.

It sometimes presents the form of branches of trees, and exhibits traces of a ligneous texture.

It burns with flame, often a little greenish; but it does not melt, like solid bitumen. It exhales, while burning, a strong, and sometimes aromatic odor, sensibly different from that of coal or bitumen.

(*Geological situation and Localities.*) Jet most frequently occurs in detached masses of a moderate size in beds of sandstone, marl, limestone, and secondary trap. It is also connected with formations of coal, particularly that, which is associated with secondary trap rocks.—It is also found with other varieties of Lignite.

Good specimens of Jet are found in Gallicia, &c. in Spain;—near Wittemberg in Saxony;—and in the department of Aude in France, where it sometimes contains amber.—In England, it occurs near Whitby.—In the Faroe islands and in the isle of Sky, it occurs in trap rocks.

* Hence its name from the Latin, *lignum*, wood.

† Jayet. *Haüy*. Lignite Jayet. *Brongniart*. Pech Kohle. *Werner*. *Hausmann*. Pitch-Coal. *Jamieson*. La Houille piciforme. *Brochant*. Jet. *Aikin*. *Phillips*.

In the *United States*; in *Massachusetts*, at South Hadley, in the coal formation. (*GIBBS*.)

(*Uses and Remarks*.) It is sometimes employed for fuel; but is more frequently cut and polished for ornamental purposes. In the department of Aude, before mentioned, more than 1000 persons are employed in the manufacture of Jet into buttons, bracelets, snuff-boxes, &c.—It has also been called Gagat—and black amber.—Some mineralogists consider it intermediate between coal and bituminous wood.

2. BRITTLE LIGNITE.* This variety may be distinguished from jet and some other combustibles, which it resembles, by its very great *brittleness*. Its surface is always cracked, and it is very easily divisible into cubical or trapezoidal fragments. Its color is black with a shade of brown, and less shining than that of jet.

The longitudinal fracture sometimes brings to view a ligneous texture; its cross fracture is even, or a little conchoidal; and its lustre is moderate.

This variety burns easily, emitting a disagreeable odor. By exposure to the air it usually bursts, and falls to pieces.

(*Geological situation and Localities*.) It is sometimes in horizontal beds of considerable magnitude; and occurs in alluvial earths, composed of sand, argillaceous marl, &c. or is connected with sandstone, basalt, &c.—It passes into the brown and earthy Lignites.—It is abundant in Bohemia and the south of France.

It is not used in the forge, but may be employed for burning lime, &c.

3. BITUMINOUS WOOD.† *JAMESON*. Its form is that of the roots, branches, or trunks of trees usually somewhat compressed; and its texture is perfectly ligneous. The longitudinal fracture is fibrous with but little lustre; the cross fracture has more lustre, is sometimes a little conchoidal, or splintery, and often discovers the concentric, annual rings of the wood. It is opaque, more friable than wood, gives a shining streak, and is very light. Its color is brown, either dark or light, and sometimes nearly brownish black, or with a shade of blue or red.

It burns with a clear flame, yielding an odor, which is very different from that of coal, and is generally rather unpleasant. Its ashes, at least in some instances, contain potash.

(*Geological situation and Localities*.) This substance, which is usually found in alluvial earths, or connected with rocks of the most recent formation, sometimes constitutes masses or beds of very considerable extent and thickness. Thus in Hanover, near Munden, it forms two beds, of which one is more than ten yards thick; the two beds are

* Lignite friable. *Brongniart*. Moor Kohle. *Werner*. Moor Coal. *Jameson*. La Houille limoneuse. *Brochant*. Trapezoidische Braunkohle. *Hausmann*.

† Bituminoses Holz. *Werner*. Holzformige Braunkohle. *Hausmann*. Le Bois bitumineux commun. *Brochant*. Lignite fibreux. *Brongniart*. Ligniform carbonated wood. *Kirwan*. Wood Coal.

separated by a thin, stony layer.—In Iceland, where it is called *Suturbrand*, it is abundant, and very distinctly exhibits the compressed trunks of trees; it is sometimes but little mineralized, and is even employed as timber.—In England, it is abundant at Bovey Tracey, near Exeter.—In Scotland, in the counties of Fife and Mid Lothian, it occurs in the coal formation.—In Prussia, it is abundant, and connected with the amber of that country.—In France, at Auteuil, near Paris; some of the trees, still entire in form, vary from 6 to 18 inches in diameter, and are penetrated with pyrites; they all lie in the same direction, and rest on a bank of chalk. Fossil bones occur in the black clay, which covers the Lignite. (*BECQUEREL*).—In the island of St. Michael, Lignite occurs in hills of pumice; it sometimes presents almost entire trees, one foot in diameter, perfectly carbonized, and apparently in their natural situation. (*WEBSTER*.)

It is, however, most frequently found in detached masses, or in small beds. It is often associated with other varieties of Lignite, into many of which it gradually passes.—The same tree is sometimes carbonated in one part, while the other remains in the state of wood.

Its fissures sometimes contain carbonate or sulphate of lime, quartz, chalcedony, sulphuret of iron, amber, &c.

In the *United States*. In *Maryland*, at Cape Sable, is a bed of Lignite from $3\frac{1}{2}$ to 4 feet thick, composed of Jet, Brittle Lignite, Bituminous Wood, and Brown Lignite; it is penetrated throughout by pyrites, and rests on sand, which also embraces pyrites. (*TROOST*).—In *Massachusetts*, at Gayhead, on Martha's Vineyard; it contains pyrites, which rapidly effloresces by exposure.

It is sometimes employed as fuel.

4. BROWN LIGNITE.* This substance, in many of its properties, resembles bituminous wood, like which it sometimes, but less frequently, exhibits the texture of wood on its longitudinal fracture; or this texture, according to Fabroni, may be brought to view by boiling the specimen in diluted nitric acid.—Its color varies from brown to brownish black.

Its general structure is often a little slaty; its cross fracture is even or conchoidal, with a resinous lustre somewhat shining. It is brittle, and varies in specific gravity from 1.20 to 1.55.

It burns with a weak flame, often bluish, and exhales an odor, which is usually disagreeable. A specimen from Bovey yielded Hatchett, water mixed with an acid and some bitumen 30.0, thick oily bitumen 10.5, charcoal 45.0, carbonic acid and carburetted hydrogen 14.5.

Its *geological situation* is similar to that of bituminous wood, into which it passes. It sometimes contains pyrites, amber, mellate of alu-

* Gemeine Braun Kohle. *Werner. Hausmann*. Common brown Coal. *Jameson*. La Houille brune. *Brochant*. Bovey Coal, or compact carbonated Wood. *Kirwan*.

mine, and resin asphaltum.—It is abundant near Exeter, at Bovey Tracey, in England, and, with bituminous wood, it forms several beds in a brownish clay.

In the *United States*, it has been observed in a few places in alluvial earths.

It is sometimes employed as fuel.

5. EARTHY LIGNITE.* Its color is nearly black, or blackish brown, or a lighter brown, and sometimes with a tinge of red, gray, or yellow. It has very little solidity, and is often perfectly friable. Its fracture is dull, fine grained earthy, but sometimes exhibits a ligneous texture. It acquires some lustre in the streak; and is but little heavier than water.

It burns, like tinder, with little or no flame, and yields an odor, which, like that of bituminous wood, is often unpleasant.

This variety differs but little from bituminous wood, except in its friability; indeed the two gradually pass into each other.

(*Localities.*) This Lignite most frequently occurs in alluvial earths, and is sometimes connected with secondary rocks in the vicinity of coal.—It is explored near Cologne, where it forms beds from 20 to 30 feet thick, which rest on white clay, and are covered by a bed of pebbles of quartz, jasper, &c. It contains trunks of trees, imbedded without order, usually compressed, of a black or reddish color, and burning very well; also fragments and fruits of a species of palm tree. The ashes of this Lignite are a little alkaline.

In the *United States*. In *Maryland*, at Cape Sable, it forms a bed from 5 to 12 feet thick, containing pyritous wood and large fragments of bituminous wood; it rests on argillaceous sandstone. (*TROOST*. See *Silliman's Jour.* v. iii, p. 8.)

(*Uses.*) It is employed as fuel in cases, where a great heat is not requisite; and for this purpose it is often moistened and formed into small, regular solids. Its ashes constitute a good manure.—The variety, found near Cologne, and sometimes called Cologne earth, or umber improperly, is employed by painters, either as a water color, or with oil.

When it contains pyrites, it affords alum, and passes into the following subvariety.

ALUMINOUS EARTH.† This scarcely differs in its external characters from the Earthy Lignite just described. It has usually a sharp taste.

It burns with some flame, and, when exposed in large masses to a moist air, it becomes warm, and sometimes takes fire.

* Erd Kohle. *Werner*. Earth Coal. *Jameson*. Bois bitumineux terreux. *Brochant*. Lignite terreux. *Brongniart*. Erdige Braunkohle. *Hausmann*.

† Alum Earth. *Jameson*. Alaunerde. *Werner*. Erdige Braunkohle. *Hausmann*. Pyritous Brown Coal. *Aikin*.

Like the other Lignites, it is found in alluvial earths; and sometimes forms extensive beds, which often embrace bituminous wood. By lixiviation it affords alum.

SPECIES 10. PEAT.

Tourbe. Brongniart. It is often called Moss in Europe.

This homely, but valuable and well known combustile, has a loose texture, more or less porous, or even spongy. When recently dug, it forms a viscid, slimy mass, which, by exposure to the air, becomes dry, hard, and more or less light and brittle in different varieties. Its color is brown, sometimes yellowish or reddish, or a dull black.

Peat consists essentially of vegetable matter in various states of decomposition; but is more or less mixed with earths and salts. It appears to differ from vegetable earth by retaining nearly *all* the principles of the vegetable, though these principles may have formed combinations, which did not exist in the living plant.

This substance burns with different degrees of ease, but sufficiently well to be employed as fuel. It leaves an abundant residue of very light ashes.

We notice two varieties of Peat, depending chiefly on the degree of decomposition in the vegetable.

*Var. 1. FIBROUS PEAT.** This variety, sometimes called Turf, is composed chiefly of vegetable fibres, variously interlaced, and united by a slimy, vegetable matter in a more advanced state of decomposition. Its texture is of course very loose. Hence we perceive the roots, stems, and leaves of the various plants, which grow in swamps, bogs, marshes, or heaths; indeed it sometimes seems to be composed almost entirely of leaves.† When dry, it is lighter and more elastic, than compact Peat, and its color is usually less dark.

2. COMPACT PEAT.‡ When recently dug, it forms a very slimy mass, soft to the touch, and sufficiently tenacious to be cut or moulded into small regular solids, like a brick. When dry, its texture becomes more or less firm and compact, and it exhibits an earthy fracture. It is harder, heavier, and blacker, than the first variety. It embraces few or no visible remains of the organic parts of vegetables, and seems to have originated chiefly from aquatic plants. In some rare instances, its fracture is glossy, like resin.

The two preceding varieties pass insensibly into each other, and frequently occur in the same bed. In this case, the upper part of the bed is loose and fibrous, having undergone only a partial decomposition; but, on approaching the lower parts, the remains of the vegetable fibre

* La Tourbe fibreuse. *Brongniart.* Turf. *Kirwan.* † La Tourbe papyracée. *Brongniart.*

‡ La Tourbe limoneuse—et piciforme. *Brongniart.* Peat. *Kirwan.*

gradually disappear, and the Peat becomes more compact, in consequence of the more complete decomposition of the vegetable, and of the pressure of the superincumbent mass.

(*Geological situation.*) This combustible is found in swamps, marshes, bogs, and low grounds, which have been, or are still covered with stagnant water. Its beds, always horizontal, are sometimes many yards thick, and either appear at the surface, or are covered by a stratum of vegetable earth. These beds, the lower part of which must once have been the bottom of ponds or small lakes, are, of course, extremely variable in extent; they are sometimes homogeneous, and sometimes contain layers of mud, sand, or clay.

Beds of Peat exhibit some peculiar characters, by which their existence may often be discovered. They possess a remarkable degree of elasticity, especially when moist; so that, if a heavy blow be impressed on one point, the bed is perceived to tremble for a considerable extent on all sides. When impregnated with water, they often swell, and their surface becomes a little convex. In this state they become so soft, that it is difficult to walk upon them, and they gradually absorb, sometimes to a great depth, any heavy body, which is placed on the surface.

Marshes or bogs, which contain Peat, are usually covered, or at least impregnated with water, for some part of the year. But, unless covered with vegetable earth, they are incapable of cultivation, and yield only coarse grasses, and certain aquatic plants.—In fine, beds of Peat sometimes rest on the surface of water, or even form small floating islands.

Beside clay, sand, and fresh water shells, other substances are occasionally found in Peat. Whole trees sometimes occur in beds of Peat, many of them lying in the same direction, and near their stumps, which appear to have been cut at nearly the same height. These facts have been observed in the Peat of Holland, Scotland, and Ireland.

Beds of Peat also embrace remains of animals, among which are deer's horns, and the bones of oxen; indeed timber, axes, and other implements of labor are sometimes found in these beds; and in the Peat of Kincardine, in Scotland, whole causeways have been observed.

(*Localities.*) Although Peat is found more or less in all countries, it is much more abundant in cold or temperate regions, than in those, which are warm. When found in warm climates, it exists at a very considerable elevation, and has seldom been observed in tropical regions.*—In Ireland, Scotland, and Holland, it occurs in large quantities.—It appears also, that, in certain parts of Holland, Peat is sometimes composed entirely of marine plants.—In many parts of the *United States*, this valuable combustible exists abundantly; particularly in the States of *Ohio*, *New Jersey*, *New York*, and *Massachusetts*.

* *Essays on the Natural History and Origin of Peat by R. Rennie.*

(*Uses and Remarks.*) This substance is cut and taken from its bed by instruments, contrived for that purpose. Sometimes a long, narrow spade, from one side of which, near the bottom, a sharp knife projects at right angles, is employed. The Peat is of course cut in two directions at once, and is taken out in solid masses of convenient length and size. The compact variety, especially when taken from water, is often moulded into the form of large bricks.—In all cases, however, the utmost care should be employed to render the Peat perfectly dry.

Peat is extensively employed as fuel in those countries, where it abounds, and where wood and coal cannot be easily obtained. This is peculiarly the case in Holland.

The compact is generally superior to the fibrous variety, as it produces a stronger and more durable heat; it also burns with a brighter flame, and a darker colored smoke. Some varieties contain much bitumen.

Peat may also be employed in several kinds of manufactures, as in burning limestone, bricks, &c.

Some varieties do not answer well for culinary purposes, in consequence of the empyreumatical oil, which they yield, while burning. Other varieties contain pyrites, and, during combustion, afford more or less of sulphurous acid gas.—Its ashes sometimes contain sulphate of iron.

(*Origin of Peat.*) A concurrence of circumstances, all of which are not perfectly well understood, is necessary to the formation of Peat. It is obvious, however, that stagnant water, impregnated with the astringent and antiseptic juices of certain plants, and a low temperature, by which many of the ingredients of vegetables are prevented from escaping in the form of gas, are among the circumstances, favorable to the production of Peat. It has been remarked, that the stagnant water of Peat grounds does not become putrid, and is less unhealthy, than that of marshes, which do not produce Peat. It is however very difficult to say, why certain marshes and bogs should be capable of converting into Peat the vegetables, which they produce, while other marshes, equally abounding with vegetables, and apparently under similar circumstances, should be incapable of yielding this combustible. Hence different opinions have been expressed on the origin of Peat; and hence some have supposed, that it depends on the presence of a particular vegetable; but they do not agree in regard to the vegetable itself.

It appears to be well ascertained, in many cases at least, that those ditches, from which Peat has been removed, will again become filled with the same combustible; but the period, requisite for this change, will vary, according as the circumstances are more or less favorable.

CLASS IV.

Ores.

The minerals, which belong to this class, generally present more definite and more uniform characters, than those of the preceding classes. Hence, in almost every systematic arrangement, the same minerals have been referred to this class. Most of the species are well defined. In a few cases, however, where several different metals are combined, it may be difficult to distinguish between those, which are essential to the species, and those which are accidentally present.

Metals, as presented by nature, are sometimes pure, or combined with each other only, and are said to exist in a *metallic state*. But more frequently they are combined with oxygen, sulphur, &c. by which their peculiar, metallic properties are more or less disguised; in this case the metal is said to be *mineralized*, and the oxygen or sulphur is called a *mineralizer*.

These two general states, in which metals are found, may conveniently be subdivided into five particulars.

1. *Native metals*. In this case the metal is pure, or alloyed with only a minute quantity of some other metal or metals.

2. *Alloys*. In this case also the metals alloyed are in a metallic state. Thus silver and antimony are found united. Sometimes more than two metals enter into the same compound. The alloy often differs much from each of its component parts in color, hardness, malleability, specific gravity, &c.

3. *Oxides*. Most of the metals sometimes occur in this state, and often abundantly. Sometimes the oxides of two metals are united.

4. *United with a combustible*. This division is chiefly composed of those various, native compounds, called *sulphurets*, in which the sulphur is commonly united with the metal, sometimes with its oxide.

5. *Metallic salts*. Here the metal always exists in the state of an oxide, united to some acid, of which the sulphuric, muriatic, carbonic, and phosphoric are the most common.

Metals, existing in the state of an oxide, or a salt, or united with a combustible, are called *ores*; and this term is by analogy extended to the native metals and alloys.

The earthy, stony, saline, or combustible substance, which contains the ore, or is only mingled with it, without being chemically combined, is called the *gangue* or matrix of the ore. Hence an obvious distinction between the gangue and mineralizer; for the latter is always *combined* with the metal, while the former is only *mixed* with it.

Sometimes the same mass contains two or more different metals, and has hence been referred to different places in the class, according as

its generic character is derived from the metal predominant in quantity, or from that, which is most rare or valuable. Hence, in a systematic arrangement, some ores may not be found under that metal, for which they are worked. Thus all ores, from which silver is extracted, are not strictly silver ores.

Metals, and their ores are sometimes disseminated in other rocks; sometimes they form irregular masses of various sizes, and sometimes they constitute beds; but more frequently they are found in veins, either filling the whole vein, or mixed with various saline and earthy minerals. They appear to be the production of every period, but more frequently exist in primitive and transition, than in secondary rocks, or than in alluvial earths.

The relative ages of the metals may be determined in a very satisfactory manner by the nature of the gangue, and by the relative position of different metallic veins. For these veins undoubtedly were once open fissures, which have since been filled by the substances, which they now contain. Hence those veins, which are most frequently intersected by others, must be older, than the veins, which intersect; and, on the other hand, those veins, which intersect all the others, must be considered the most recent. According to these principles, molybdena and tin are among the most ancient metals, while lead, copper, &c. belong to later formations. Iron is a production of every period.

The term *mine* is usually applied to those places, whence the ores of metals are, or may be, extracted in considerable quantities, but is sometimes extended to deposits of combustibles, salts, or even of earthy minerals.

We shall now briefly describe the physical properties of metals in a state of purity.

1. *Density, or specific gravity.* The specific gravity of metals, if we exclude those recently discovered by Sir H. Davy, is always greater than that of the minerals, which compose the preceding classes; tellurium, the lightest metal, being above 6.0, while the heaviest earthy body is less than 5.0.

2. *Opacity.* Metals are almost perfectly opaque. Hence the thinnest layers of gold, which are applied to the surface of porcelain, remain opaque; still, however, this metal, when in leaves extremely thin, transmits a feeble light.

3. *Lustre.* Metals, especially when polished, reflect light very copiously, and hence possess that peculiar kind of lustre, which is called *metallic*. Even when reduced to a coarse powder, they retain more or less of their lustre. The metallic lustre, which some earthy minerals possess, is confined to the surface.

4. *Color.* Each metal, when pure, uniformly presents its proper color; the light being reflected from the integrant particles, and not from any foreign mixture. Their general color is some shade of white, gray, or yellow.

5. *Malleability.* It is in consequence of possessing this property, that some metals may be extended into very thin leaves, either by beating them with a hammer, or pressing them between rollers. All the metals are not sensibly malleable; and those, which are so, exhibit this property in very different degrees.

6. *Ductility.* By this property metals are rendered capable of being drawn into wires, more or less fine. But, although the ductile metals are also malleable, yet these two properties do not always correspond in the same metal. Thus iron is ductile in a much higher degree, than it is malleable.

7. *Tenacity.* The two preceding properties must, in fact, ultimately depend on the *tenacity* of the metal; and this seems to arise from the power, which certain metals possess, of permitting their particles to move among themselves without being forced beyond the limits of their mutual attraction. The *tenacity* of metals, however, is usually estimated by the strength of their wires; and different metals may be compared in this respect, by taking wires of a given diameter, and gradually adding weights to one of their extremities, till the wires break.

8. *Hardness.* This property is possessed in only a moderate degree by most of the metals, but may be increased by artificial processes. When the ductility and softness of metals have been removed, they may be restored by heating the metal, and permitting it to cool slowly.

9. The *elasticity* of metals follows very nearly the same order as their hardness, and may be artificially increased in the same manner.—The peculiar *sound*, which some metals yield, after being struck, is connected with their hardness and elasticity.

10. Although the metals are well known to be the best *conductors of electricity*, yet it appears from the experiments of Haüy, that, when insulated, they acquire a feeble electricity by friction with cloth.

11. Some of the metals possess a slight degree both of *taste* and *odor*.

12. Several of the metals, when melted, may be regularly crystallized. The process consists in permitting the melted mass to cool at the surface; and the solid crust being pierced, the internal, liquid part is poured out, leaving crystals attached to the sides of the cavity.

Action of Caloric. The metals are all expansible by caloric, and the degree of expansion appears to be nearly in the order of their fusibilities.—The scale of fusibility extends from mercury, which becomes fluid at about 40° below zero on Fahr. to iron, which melts at about 158° W. and thence to platina, which can be melted by the most intense

heat only.—Melted metals, if the quantity be small, assume a globular form; and a metal, thus purified by fusion, was formerly called a *regulus*.

Many, and perhaps all, of the metals may be volatilized by heat; but, in general, they must be previously melted; arsenic, however, is volatilized at a lower temperature, than its melting point.

The more valuable metals may be arranged in nearly the following order in regard to their most important physical characters; beginning in each case with the metal, which possesses the property in the highest degree.

<i>Spec. gravity.</i>	<i>Lustre.</i>	<i>Malleability.</i>	<i>Tenacity.</i>	<i>Hardness.</i>	<i>Fusibility.</i>
Platina.	Iron or steel.	Gold.	Iron.*	Iron.	Mercury.
Gold.	Silver.	Silver.	Copper.	Platina.	Tin.
Mercury.	Platina.	Platina.	Platina.	Copper.	Lead.
Lead.	Mercury.	Copper.	Silver.	Silver.	Silver.
Silver.	Gold.	Iron.	Gold.	Gold.	Copper.
Copper.	Copper.	Tin.	Tin.	Tin.	Gold.
Iron.	Tin.	Lead.	Lead.	Lead.	Iron.
Tin.	Lead.				Platina.

GENUS I. GOLD.

This metal, when pure, has a fine yellow color, slightly tinged with red, and acquires, when polished, a high lustre. In malleability it is superior to all the other metals. Its ductility is also very great. It is softer than silver, and may easily be cut by a knife. Its specific gravity is about 19.3.

Gold is not oxidated by exposure to air or moisture; nor is this effect produced by caloric, unless at a very high temperature, such as that excited by electricity. It also burns in the flame of a united stream of oxygen and hydrogen gases. It melts at about 32° W. Nitromuriatic acid is its proper solvent.

(*Uses and Remarks.*) The uses of Gold in jewellery and the ornamental arts are too numerous and too well known to be here enumerated. When employed in the arts, or for coin, it is alloyed, sometimes with silver, but more frequently with copper, or with a mixture of copper and silver, to increase its hardness. The best proportion for the alloy appears to be that, in which the copper, or the compound of copper and silver, constitutes one twelfth part. This is the standard Gold of England and the United States. Copper heightens the orange tinge of Gold; silver in the proportion of about one fifth part renders it greenish; and the addition of a little iron gives it a bluish tint.

* According to the experiments of Sickengen. *Ann. de Chimie*, t. xxv.

The purity of gold coin, &c. is estimated by supposing a given mass divided into 24 equal parts, called *carats*; and hence, if this mass be alloyed with 2 parts of copper or silver, it is said to be 22 carats fine.—The purity of Gold may also be determined with considerable accuracy by means of the touchstone. (See Basanite.)—The purple oxide of Gold communicates to glass or enamel a rich red or purplish tinge; as appears in the painting of porcelain.

SPECIES 1. NATIVE GOLD. KIRWAN.

Gediegen Gold. *Werner. Hausmann.* Or natif. *Haüy. Brongniart. Brochant.* Hexahedral Gold. *Jameson.* Native Gold. *Aikin. Phillips.*

Native Gold is very seldom, if ever, perfectly pure; but is alloyed with minute quantities of other metals, which sometimes considerably affect its color. When the Gold contains very little alloy, its color scarcely differs from a pure gold yellow;* but it thence varies, according to the nature and quantity of the alloy, to orange yellow, brass yellow,† greenish yellow, and even passes to grayish yellow,‡ which sometimes inclines to steel gray; sometimes also the yellow has a tinge of brown.

Native Gold appears under various forms. It is sometimes crystallized in cubes or octaedrons, either of which may be its primitive form; sometimes in cubes or octaedrons with truncated edges or angles; also in dodecaedrons with rhombic faces, and in solids with twenty four trapezoidal faces. The crystals are usually small and imperfect.—It also presents various imitative forms, as dendritic, ramous, capillary, reticular, filiform, like moss, or in leaves, or membranes; in fine, it very often occurs in spangles or grains, sometimes called *Gold Dust*, or in small masses, variable in size, and often flattened. These grains or masses are frequently loose and insulated, and sometimes disseminated in other minerals.

It is malleable, easily cut by a knife, and has a metallic lustre. Its specific gravity varies from 12.0 to 19.0, according to the proportion of alloy.

(*Chemical characters.*) Native Gold is soluble in the nitromuriatic acid; and from this solution, which is yellowish and tinges the skin purple, the Gold is precipitated in a metallic state by the green sulphate of iron. The metals, by which native Gold is alloyed, are silver, copper, iron, palladium;§ and even platina is said to exist in some Gold. The alloy sometimes consists of two or more of the preceding metals. A specimen from Bohemia yielded Lampadius Gold 96.9, silver 2.0, iron 1.0.

* Gold-yellow native Gold. *Jameson.* † Brass-yellow native Gold. *Jameson.*

‡ Grayish yellow native Gold. *Jameson.*

§ The existence of palladium in Gold was first discovered by Mr. J. Cloud of Philadelphia, in some ingots from Brazil, deposited in the Mint of the United States.

Native Gold may be distinguished from sulphuret of iron and pyritous copper by its malleability and greater specific gravity—and from platina by the metallic precipitate, which it affords with sulphate of iron.

Gold, in small quantities, is often so completely enveloped in other minerals, that it is invisible by the eye, but may still be worth the labor of extraction. In this case, the mineral, supposed to contain it, may be triturated with mercury, which dissolves the Gold; and the mercury is then to be evaporated to dryness. If Gold be present, but in too small quantity to be visible to the eye, the residue, after evaporating the mercury, may be dissolved in nitromuriatic acid; and a yellowish solution, capable of tinging the flesh purple, will be obtained. Sometimes it is expedient to roast the ore before trituration.—Among those ores, that often contain small quantities of metallic Gold in a state of mixture, which may be extracted, as already mentioned, are the sulphurets of iron, lead, zinc, and mercury, pyritous copper, and native tellurium; and in most of these minerals it is almost impossible to determine the presence of the Gold by any external character.

SUBSPECIES 1. ARGENTIFEROUS NATIVE GOLD. AIKIN.

Argentiferous Gold. Jameson. Phillips.

Its color varies from brass yellow to nearly silver white. It is sometimes dentiform, or in plates, and sometimes in imperfect crystals.

A specimen yielded Klaproth gold 64, silver 36. It is insoluble in nitric or nitromuriatic acid.

It has been found in Siberia at Schlangenberg, associated with sulphate of barytes or hornstone.

(*Geological situation of Native Gold.*) Gold is sometimes in veins; sometimes disseminated in rocks or ores of other metals, or in leaves or ramifications attached to their surfaces; and sometimes in loose grains or masses in alluvial earths. The veins, which contain it, are, in most cases, composed chiefly of quartz, and may traverse granite, gneiss, mica slate, &c. It occurs also in metallic veins in porphyry, hornblende, greenstone, and limestone; and sometimes in veins, which traverse gray wacke and other transition rocks.—In addition to quartz, other minerals, as jasper, feldspar, carbonate of lime, sulphate of barytes, &c. sometimes constitute the gangue of Gold.—The ores, which most frequently accompany Gold, are the sulphurets of iron, silver, lead, and antimony, pyritous copper, red silver ore, and arsenical iron.

In a few instances Gold has been observed in minerals of secondary formation.

But much of the Gold of commerce is found in grains or small masses, disseminated in those alluvial deposits of sand, gravel, and pebbles, which constitute certain plains, or form the margin or the bed of rivers.

Auriferous sands, whether siliceous or argillaceous, are almost always ferruginous. Hence their color is usually reddish or blackish. Hence also the opinion, that the Gold in ferruginous earths has proceeded from the decomposition of sulphuret of iron, containing Gold.

The Gold, which exists in the sands of certain rivers, does not, in most cases at least, appear to have been detached by the waters from those ores or rocks, over which they may have passed during their course. Several facts strongly support this opinion. In almost all rivers, whose sands are auriferous, the Gold is confined to a limited, and often comparatively small, part of the course of the river; and, instead of becoming more abundant, as the river is ascended toward the supposed source of the Gold, it diminishes in quantity, and at length often disappears. Thus the Rhine furnishes less Gold near Basle, than toward Strasburg, although the former is nearer to the mountains, whence the river proceeds. Thus also the sands of the Danube contain no Gold, while this river is traversing a mountainous country in the bishopric of Passau; but in the plains below Efferding its sands become auriferous.

It may indeed be said, that the rapidity of the current prevents any deposite of Gold, till a river reaches a level country, and becomes more tranquil. But in this case, when a river traverses broad vallies, and thereby loses much of its velocity even in mountainous countries, the Gold, which it transports, ought to be deposited. This does not, however, appear to be often the case. Further, the river Tesino has no auriferous sand till it has passed through the lake Maggiore; but whatever Gold this river might have brought from the mountains of Switzerland would undoubtedly have been deposited, while traversing this lake, where its current is comparatively slow. (*BRONGNIART.*)

It appears exceedingly probable from the preceding and similar examples, that the Gold, which exists in the sand of many rivers, has been washed from the plains, which they traverse. In fact, the sand of these plains is known in many instances to contain Gold; and the sand of rivers and brooks is usually more auriferous immediately after storms, during which much water and sand must have passed from the plains into the contiguous streams. The sand of the river Nera, in Hungary, is even less auriferous, than that of the plain, contiguous to the river.—Still it must be admitted, that the Gold of these plains may have been deposited by some ancient alluvion of a different nature, perhaps, and more extensive, than that of rivers; and hence may originally have proceeded from primitive mountains.

The Gold is usually most abundant in the reentering angles of rivers. If 100 pounds of sand contain from 20 to 30 grains of Gold, they are worth the labor of *washing*, by which process this precious

metal is extracted from them. One hundred pounds of sand from some of the African rivers yield about 1200 grains of Gold.—The largest masses of alluvial Gold, hitherto found, have not much exceeded thirty pounds.

(*Localities.*) Gold is very abundantly diffused, although in most countries it is found in small quantities only.

Spain and Greece appear to have furnished the ancients with considerable quantities of Gold ;—but the mines of the former have been abandoned since the discovery of America.

Many of the rivers of Europe contain auriferous sand. This is the case with certain portions of the Rhine, the Rhone, the Garonne, the Danube, Tagus, &c.

In Germany, Gold mines are explored in the mountains, which traverse the Salzburg.

In Ireland, in the County of Wicklow, it is found in a quartz, ferruginous sand, and also in a stream, which runs over argillaceous slate, traversed by veins of quartz. This Gold is associated with oxide and sulphuret of iron, oxide of tin, and ferruginous oxide of tungsten, in the last of which threads of Gold are sometimes observed.—In England, Gold has been found in alluvial deposite in Cornwall ; and at North Moulton in Devonshire, it is disseminated in a ferruginous quartz rock.—In France, at Gardette, in a vein of quartz, traversing gneiss.

Hungary, however, is the only country in Europe, whose mines and auriferous sands yield any considerable quantities of Gold. Their annual produce is estimated at about 1700 pounds Troy. (*BRONGNIART.*)—In Transylvania, are the Gold mines of Nagyag and Offenbanya, where this metal is united with tellurium, lead, and silver.

In Siberia, are valuable mines of Gold, whose annual produce is estimated at about 4500 pounds Troy. These mines exist at Schlangen-berg, Beresof, &c. and at the latter place is found auriferous sulphuret of iron partially decomposed.

Gold is also found in the islands of Java, Borneo, and Sumatra, in the last of which about 15,400 ounces are annually collected.

Africa, which furnished the ancients with much Gold, still abounds with this precious metal ; and there is reason to believe, that most of it proceeds from alluvial earths. The mines of Kordofan are situated between Darfoor and Abyssinia.—Other Gold mines are found in the western part of Africa, south of the great desert Zaara, near the foot of those mountains, which contain the sources of the Senegal, and Gambier. The sands of these rivers are also auriferous.—Much Gold is also obtained from the kingdom of Bambouk, northwest of the mountains just mentioned, where it is found in grains or spangles in a ferruginous

earth.—The country of Sofala, on the southeast coast of Africa, appears also to furnish much Gold. This is by many supposed to be the Ophir, whence Solomon obtained Gold in such abundance.

But America, particularly South America, contains the most valuable Gold mines; of which the most important are found in Brazil, New Grenada, Chili, New Spain, and Peru.

The annual produce of the Gold mines of South America and New Spain is probably between 35,000 and 40,000 pounds Troy; of which more than one third is furnished by Brazil, where it is obtained chiefly by washing auriferous sands. Gold is, in fact, found at the foot of the Andes through almost their whole extent.—The Gold of Peru is sometimes embraced in veins of quartz, traversing primitive rocks.—The Gold of Brazil is sometimes found in carbonate of lime, and sometimes in a conglomerate or sandstone, containing pebbles of quartz, and resting on gneiss or other primitive rocks.—In Mexico, Gold occurs in veins of quartz, traversing gneiss and mica slate; and is also found in most of the veins of silver ores in that country. (*HUMBOLDT.*)

In the *United States*; in *North Carolina*, in Cabarras County, on Meadow Creek, &c. The Gold occurs in grains or small masses in alluvial earths, and chiefly in the gravelly beds of brooks in the dry season. (*GIBBS.*)—According to Mr. Ayres, one mass, weighing 28 pounds, has been discovered.—The Gold of Cabarras is alloyed with silver and a little copper. When purest, it is 23 carats fine, and is superior in quality to the Gold coins of England and the United States. In 1810, upwards of 1341 ounces of this Gold, equal in value to 24,689 dollars, had been received at the mint of the United States. (*Bruce's Min. Journ. vol. i.*)—It is said also to have been found on the upper branches of James' River; and on the Catabaw in *South Carolina*.

It appears from the preceding details, that most of the Gold of commerce is obtained from auriferous sands. When thus found, it is extracted by the simple process of washing the sand. When enveloped in other minerals, it is extracted by amalgamation with mercury.

(*Remarks.*) According to Humboldt,* the annual produce of the Gold mines of South America and New Spain is in value but little short of 11 millions of dollars; of which Brazil furnishes about $4\frac{1}{2}$ millions, New Grenada about 3 millions, Chili about $1\frac{2}{3}$ million, New Spain about 1 million, Peru and Buenos Ayres the remainder. The quantity of silver, annually furnished by the same countries, is between 40 and 50 times greater than that of Gold. The same author has also estimated the value of the whole quantity of *Gold* and *Silver*, extracted from the same mines, between the years 1492 and 1803, at 5,706,700,000 dollars.

* Political Essay on New Spain.

GENUS II. *PLATINA*.

Platina has a grayish white color, approaching that of silver, but with less lustre. Its hardness is somewhat inferior to that of iron. When fused and hammered, its specific gravity lies between 20 and 22, but varies according to the process, by which it has been purified, and the degree of hammering, it has undergone.

It is a slow conductor of caloric; and, with the same degree of heat, expands considerably less than steel, like which it may be rendered very elastic. Like iron also, it softens so much below its melting point, that it is capable of being *welded*.

Platina is infusible by itself in the best furnaces; but may be melted in the focus of a powerful mirror, or even by the blowpipe with the aid of oxygen gas. (*HENRY.*) Before the compound blowpipe it is melted and volatilized with strong ebullition. (*SILLIMAN.*) It is not oxidated by exposure to the air, nor by a very strong heat; nor is its lustre changed by boiling nitric acid. It is soluble in nitromuriatic acid, yielding a muriate of Platina, from which muriate of ammonia throws down a yellow precipitate, consisting of muriate of Platina and ammonia. A solution of muriate of Platina, so diluted as to resemble water, is made to assume a bright red color by the addition of a few drops of recent muriate of tin.

The various processes of purifying native Platina, proposed by De Lisle, Jeannety, Tilloch, and Count Poushkin, may be found in most systems of chemistry.

(*Uses.*) The physical characters of pure Platina, particularly its hardness, infusibility, and resistance to the action of air and moisture, indicate the important uses, to which it may be applied. Thus it is employed for crucibles, spoons, evaporating vessels, pendulums, pyrometers, &c. It is also well adapted to the construction of reflecting mirrors for telescopes, as it strongly reflects light, and does not tarnish by exposure to the air. It may also be employed for the pendulum-springs of watches. The little expansion, which it undergoes by exposure to heat, renders it an excellent standard of measures of length. Rods of this metal were employed by Delambre and Mechain in the measurement of the base of a series of triangles to determine the length of an arc of the meridian. It has also been used in the painting of porcelain; and, by alloying it with gold, different shades of color may be produced.

SPECIES 1. NATIVE PLATINA. *JAMESON*.

Gediegen Platin. *Werner*. Platin. *Hausmann*. Platine natif ferrifere. *Hauy*. Platine natif. *Brongniart*. *Brochant*. Platina. *Kirwan*. Native Platina. *Aikin*. *Phillips*.

This metal occurs in grains, which are usually flattened, and sometimes in small masses, the largest of which are about the size of a

pigeon's egg. Its color is between light steel gray and silver white, with a shining metallic lustre. It is somewhat less hard than iron; malleable, and, in thin plates, flexible. Its specific gravity is between 15.60 and 18.94.

(*Chemical characters.*) These grains are soluble in nitromuriatic acid, leaving a blackish residue of about 3 per cent. consisting of iridium and osmium; the solution, when concentrated, has a deep reddish brown color, and yields, on the addition of muriate of ammonia, a yellowish precipitate. It is infusible by the blowpipe. Native Platina is not pure, being in fact alloyed with small quantities of seven or eight other metals, viz. iron, copper, lead, and also four other metals, unknown till they were discovered in Platina. These new metals are osmium, rhodium, iridium, and palladium.

Among the grains of Native Platina are some, which are harder and heavier than the others, not malleable, and scarcely soluble in nitromuriatic acid; these, according to Wollaston, are an alloy of iridium and osmium.

(*Geological situation and Localities.*) Nothing is known of the original situation of Platina. It has hitherto been obtained chiefly from a few districts in South America, in alluvial deposits. In the districts of Novita and Citara, in the province of Choco, in New Grenada, the Platina is mixed with magnetic iron sand, gold, titanium, spinelle, quartz, &c. it is sometimes even penetrated by magnetic iron. In the same earths are found fragments of greenstone, and rolled masses of basalt, containing olivine and augite. It occurs also near Barbacoa in Popayan.—More recently, Platina has been found in some of the gold mines of Brazil, and, according to Dr. Wollaston, is purer than that from Peru; it is mixed with grains of native palladium nearly pure.—Vauquelin has also discovered small quantities of Platina in some of the gray copper ores from Guadalcanal in Estremadura; it does not contain any of the four new metals already mentioned.—Platina has also been found in the eastern part of St. Domingo, in the sands of the river Jaki, at the foot of the mountains of Sibao.—It is also said to have been found near Carthagená; in Barbadoes, &c.; but the authority is by some considered doubtful.

(*Remarks.*) Large masses of Native Platina are extremely rare. One, presented by Humboldt to the King of Prussia, weighs 1088.3 grains.—Another, now in the Royal Museum at Madrid, weighs 1 lb. 9 oz. 1 dr. Its form is somewhat oval. (*HEULAND.*)—Both these masses proceeded from Choco in South America.

The word, *Platina*, is said to be a diminutive of the Spanish word *Plata*, which signifies silver. Platina was first made known in Europe by Don Ulloa about 1748.

New Metals in Platina. We have already remarked, that four metals, previously unknown, had been discovered in Native Platina. Two of these we shall here describe, while the other two will form distinct genera.

1. OSMIUM. *TENNANT.* Of this substance in a metallic state little is known, except that it exists in the form of a dark gray or bluish powder. If the black powder, which remains after dissolving Platina in nitromuriatic acid, be distilled with nitrate of potash, a volatile oxide of Osmium sublimes, and, when cool, is condensed into a solid, colorless mass. This oxide is very soluble in water; and, if an infusion of galls be added to this colorless solution, it produces a purple color, which soon changes to a deep and lively blue. The pungent odor of its volatile oxide suggested the name of the metal.

2. RHODIUM. *WOLLASTON.* This substance has not yet been sufficiently investigated. It is not malleable, and has a grayish white color. It is infusible; and insoluble in acids. But, when alloyed with copper, lead, or platina, it becomes soluble in nitromuriatic acid. With arsenic it is fusible; and, by continuing the heat, the arsenic is driven off. Its specific gravity appears to be above 11.—Its name is taken from the rose color, which it communicates to dilute solutions of salts, which contain it.

GENUS III. *IRIDIUM.* *TENNANT.*

This metal resembles Platina in color and infusibility; but it is not malleable. No simple acid dissolves it; and even the nitromuriatic has but a very feeble action. It, however, becomes oxidated by fusion with potash or soda; and this oxide is soluble in the sulphuric, muriatic, or nitric acid. The first two acids give green solutions, which become blue by dilution with water; but the nitric solution, when concentrated, is red. All these solutions give, by the addition of an alkali, a precipitate of the same color as the solution. Its name was suggested by the variety of colors, it exhibits, while dissolving in muriatic acid.

SPECIES 1. NATIVE IRIDIUM.

Iridium. Jameson. Alloy of Iridium and Osmium. Wollaston. Aikin. Phillips.

Its color is steel gray, somewhat paler than that of native platina. It is sometimes crystallized in six-sided prisms, either perfect, or truncated on the terminal edges. But it usually occurs in small, irregular, flat grains, with a shining metallic lustre. It has a foliated structure; is brittle; and somewhat harder than native platina. Its specific gravity is 19.5.

Native Iridium is always alloyed by Osmium. It is not acted upon

by nitromuriatic acid, and may thus be separated from grains of native platina. By fusion with nitre it acquires a dull, black color, but regains its original lustre and color by heating it on charcoal.

It has been found only in South America, where it is associated with native platina in alluvial deposite.

GENUS IV. *PALLADIUM*.

Its color is grayish white, and scarcely distinguishable from that of Platina. It is malleable, very ductile, and, in thin plates, flexible, but without much elasticity. Its hardness differs but little from that of wrought iron; and its specific gravity is somewhat above 11. It is not oxidated by the action of air and caloric; but in a high heat is fusible. It forms ductile alloys with gold and silver, and very much debases their color. (*CLOUD*.) In nitromuriatic acid it rapidly dissolves, yielding a deep red solution, from which is obtained a yellowish white precipitate by prussiate of mercury, which does not throw down platina. The muriate of Palladium and potash crystallizes in four-sided prisms, which, being viewed at right angles to the axis, appear green, but, in the direction of the axis, are red. (*BRONGNIART*.)

SPECIES 1. NATIVE PALLADIUM. *WOLLASTON*.

Palladium. *Jameson*. *Aikin*. Native Palladium. *Phillips*.

Its color is pale steel gray, passing to silver white. It occurs in small, opaque grains, which have a metallic lustre, and appear to be composed of diverging fibres. Its specific gravity is between 11.8 and 12.15.

It is infusible by the blowpipe; but is rendered fusible by the addition of sulphur. By continuing the heat, the sulphur is volatilized, and malleable Palladium remains.—It is alloyed with a little platina and iridium.

Its grains differ from those of platina both in structure and specific gravity.

It has been found in Brazil in alluvial deposite with grains of platina and gold.

GENUS V. *SILVER*.

Pure silver is very nearly white. In lustre it is superior to gold, but in malleability is somewhat inferior. It is very ductile, and the tenacity of its wire is inferior only to that of iron, copper, and platina. It is a little harder than gold, more elastic, and more sonorous by percussion. But it is softer than copper, and easily cut by a knife. Its specific gravity is 10.47.

Silver melts at about 23° W. It is not oxidated by exposure to the air, but acquires a tarnish, which arises from the action of sulphuretted hydrogen. It is not oxidated even by the action of caloric, unless at a high temperature long continued, or by the heat, produced by oxygen gas. Nitric acid is its proper solvent, from which it is precipitated by muriatic acid in the state of a white, insoluble substance, which, by exposure to the sun's rays, speedily assumes a violet or blackish tinge. Or it may be precipitated in a metallic state by a plate of polished copper.

(*Uses and Remarks.*) Silver, it is well known, is employed for coin, vessels of use, works of ornament, and for plating copper, &c. In these cases, however, it is usually alloyed with a little copper, which increases its hardness and renders it more sonorous, without debasing its color. The standard silver of the British coins contains 18 pwts. of copper in 1 lb. Troy of silver; and in the United States, 1664 grains of silver contain 179 grains of copper.

Silver is soluble in the nitrosulphuric acid, prepared by dissolving one pound of nitre in eight or ten pounds of strong sulphuric acid. This compound acid, which dissolves about one fifth of its weight of silver, does not act upon copper, lead, or iron; and hence may be economically employed for recovering silver from old, plated goods. The plated copper is added in small pieces to the acid, which should be frequently stirred, and kept at a temperature of between 100° and 200° Fahr. Muriate of soda precipitates the silver in the state of a muriate, which may be reduced by fusion with carbonate of soda.

The oxide of silver communicates an olive color to glass or enamel; and the nitrate of silver constitutes the basis of indelible ink.

Silver is usually extracted from its gangue or its ores by amalgamation with mercury, or by roasting and cupellation with lead. But it must be remembered, that all ores, which contain sufficient quantities of silver to be worth extraction, are not, strictly speaking, ores of Silver. (See geological remarks on the Ores of Silver.)

SPECIES 1. NATIVE SILVER. KIRWAN.

Gediegen Silber. *Werner.* Hausmann. Argent natif. *Hauy.* Brongniart. Brochant. Hexahedral Silver. *Jameson.* Native Silver. *Aikin.* Phillips.

Its general characters are those of pure Silver, though it is usually a little less white, less soft, and less malleable. Its surface is frequently tarnished with shades of gray, yellowish brown, grayish black, &c.

Native Silver is sometimes crystallized, and appears in cubes, octaedrons sometimes cuneiform, cubo-octaedrons, &c. The crystals are usually small, often aggregated, and sometimes so arranged, as to produce certain imitative forms. Sometimes it is branched or dendritic, presenting numerous crystals, attached to each other; when

the branches all lie in the same plane, the form becomes reticulated, or resembles the leaf of a fern.—It also occurs cylindrical, dentiform, filiform, or capillary; and sometimes its filaments are curved, twisted, entangled, or even collected into little tufts, like those of thread or hair. In fine, it sometimes appears in leaves, plates, or spangles, or in amorphous masses, which in some cases are very large. It but rarely occurs in grains.—Its specific gravity is between 10.0 and 10.5.

(*Chemical characters.*) Its relations to acids are nearly the same as those of pure silver. Sometimes, however, it will not dissolve in nitric acid, unless it has been previously melted. Native Silver is seldom, if ever, perfectly pure, being alloyed with small quantities of gold, copper, arsenic, iron, antimony, &c. The quantity of alloy is seldom less than 4 or 5 per cent.

Its malleability and other obvious characters are sufficient to distinguish it from antimonial silver, native antimony, &c.

SUBSPECIES 1. AURIFEROUS NATIVE SILVER.

Guldishes gediegen Silber. *Werner.* Auriferous Native Silver. *Kirwan. Jameson. Aikin. Phillips.*

This ore, which is rare, occurs in small masses, or in leaves, or is capillary, or in cubes. Its color is yellowish white, or nearly brass yellow; and its specific gravity is greater than that of pure Silver.

A specimen from Norway yielded Fordyce silver 72, gold 28. It sometimes contains copper.

This mineral has been found at Kongsberg in Norway; Schlangenberg in Siberia; and Cronebane in Ireland.

(*Geological situation and Localities of the Species.*) Native Silver is connected with various other minerals, being disseminated in their masses, inserted in their fissures, or attached, often under some imitative form, to their surfaces. It accompanies nearly all the other ores of Silver in veins, which traverse primitive or transition rocks. It has also been observed in secondary rocks, as sandstone and limestone.—Its gangue may be quartz, carbonate or fluuate of lime, sulphate of barytes, &c. It is often associated with the sulphurets of iron, zinc, and lead, pyritous copper, and sometimes with native bismuth and arsenic, and the ores of cobalt and nickel.

Native Silver is found in the mines of Mexico and Peru, where it is often associated in veins with the sulphuret of silver, pyrites, &c.; it is sometimes disseminated in an ochreous brown oxide of iron, and this mixture is called *Pacos* in Peru.—The mines of Huantajaya, in Peru, surrounded by beds of muriate of soda, have furnished large masses of Native Silver.—At the mines of Gualgayoc, La Pampa de Navar, &c. filaments of Native Silver are sometimes found immediately under the soil.—In Norway, at Kongsberg, where its gangue is carbonate

of lime, sulphate of barytes, &c.—In Saxony, at Freyberg, in sulphate of barytes and brown spar.—In France, at Allemont, in a ferruginous clay, &c.—In England, in Cornwall, it is in veins, traversing argillite;—and in Dartmoor, it occurs capillary with crystallized sulphuret of silver in quartz.

In the *United States*. In *New Jersey*, it has been observed ramous or branched.—In *New York*, near Sing-Sing, in a very small vein. (*GIBBS*.)—In *Connecticut*, at Huntington, with native bismuth and argentiferous sulphuret of lead; this silver contains a little arsenic, and does not dissolve in nitric acid, till it has been fused. (*SILLIMAN*.)—In *New Hampshire*, near Portsmouth, has been found on the top of a wall a small mass, 3 or 4 inches in diameter, composed principally of Native Silver in filaments; the surrounding hills are chiefly greenstone. (*J. F. DANA*.)

In a few instances very large masses of Native Silver have been found. Thus the mine of Kongsberg has furnished one, weighing 560 pounds. A still larger mass is said to have been found at Schneeberg in Saxony; and it is added, that Albert, Duke of Saxony, in 1478, descended the mine, and used this immense block of Native Silver, as his dining table.

SPECIES 2. ANTIMONIAL SILVER. JAMESON.

Spiesglaz Silber. *Werner*. Argent antimonial. *Hauy*. *Brongniart*. *Brochant*. Antimoniated native silver. *Kirwan*. Silber Spiesglanz. *Hausmann*. Antimonial Silver. *Aikin*. *Phillips*.

Its true color is nearly silver white, sometimes inclining to tin white. Its surface, however, has often a tinge of yellow, or reddish yellow, or is invested with a blackish coat; but its streak is metallic and shining.

Its structure is foliated; and its lustre metallic and shining, sometimes very highly. It yields to the knife, possesses little or no malleability, and may be broken without difficulty. Its specific gravity varies from 9.44 to 10.0.

This ore is sometimes in grains, and sometimes in nodules or masses, composed of granular distinct concretions. Frequently, however, it appears in hexaedral or cylindrical prisms, whose sides are, in general, deeply and longitudinally striated. A four-sided prism, and some other forms are also mentioned.

(*Chemical characters*.) Antimonial Silver, according to Klaproth, contains from 76 to 84 parts of silver, and from 16 to 24 parts of antimony. It melts before the blowpipe; the antimony is oxidated, and rises in a white smoke, yielding its peculiar odor; a globule of silver is also obtained, more easily however, if borax be added. In nitric acid it becomes covered with a white oxide of antimony, and is reduced to a kind of pap. (*BRONGNIART*.)

(*Distinctive characters.*) Its foliated structure and want of malleability distinguish it from native silver.—The same structure also distinguishes it from arsenical iron and arsenical cobalt, the former of which is also harder, and yields an odor of garlic, when struck with steel, and the latter communicates to borax a blue tinge.

(*Geological situation and Localities.*) This species occurs in metallic veins, but is somewhat rare. Near Guadalcanal, in Spain, it occurs in carbonate of lime and sulphate of barytes. It is associated with sulphuret of lead, native silver, and sometimes with gray copper, &c. It is found also at Wittichen, &c. in Suabia;—and in the Harz, &c.

SPECIES 3. ARSENICAL SILVER. JAMESON.

Arsenik Silber. *Werner.* Argent arsenical. *Brongniart. Brochant.* Argent antimonial ferro—arsénifère. *Haüy.* Arsenicated native silver. *Kirwan.* Arsenical antimonial Silver. *Aikin. Phillips.*

Its color differs little from that of the preceding species, except in sometimes inclining to lead gray. It has often a steel gray, or blackish tarnish, but its streak has a metallic lustre.—Its structure is less distinctly foliated, than that of antimonial silver; and its fracture, which is usually foliated, is sometimes even or conchoidal; its lustre is metallic and more or less shining. It is broken without difficulty, and easily yields to the knife. Its specific gravity is about 9.44.

It is sometimes reniform, globular, or botryoidal, and sometimes in irregular masses, composed of granular concretions.

(*Chemical characters.*) When exposed to the blowpipe, it exhales a strong odor of garlic, in consequence of the volatilization of the arsenic; and a globule of silver, contaminated with iron, remains. A specimen from Andreasberg yielded Klaproth silver 12.75, arsenic 35.0, iron 44.25, antimony 4.0; = 96.

Its softness distinguishes it from arsenical iron; but its claims to the rank of a distinct species are somewhat questionable. It has indeed been referred by some mineralogists to the preceding species.

(*Localities.*) It is found at Andreasberg in the Harz, in carbonate of lime, accompanied by native arsenic, the sulphurets of lead and zinc, and red silver ore; it is sometimes in little spheres, aggregated into botryoidal masses. It occurs also in Suabia; but is a rare mineral.

SPECIES 4. SULPHURET OF SILVER.

Argent sulfuré. *Haüy. Brongniart.* Glaserz. *Werner.* Hexahedral Silver-Glance. *Jameson.* L'Argent vitreux. *Brochant.* Sulphurated silver ore. *Kirwan.* Sulphuretted Silver. *Aikin. Phillips.* Dichtes Glanzerz. *Hausmann.*

The color of this ore is almost always a dark lead gray. By exposure to the air its surface becomes darker, or acquires an irised tarnish; but its streak is shining.

It is considerably malleable, and not easily broken. It yields with much ease to the knife, which leaves a shining, metallic surface, and the slices detached are flexible. Its specific gravity usually lies between 6.90 and 7.21.

This mineral is sometimes crystallized in cubes, octaedrons, cubo-octaedrons, and dodecaedrons with rhombic faces; and some of these forms are subject to truncations on their edges or angles. The crystals are usually small and grouped.—It, however, more frequently occurs in amorphous masses, or leaves, plates, or membranes, or is dendritic, filiform, capillary, reticulated, &c. Its masses are never very large.

Its fracture is usually fine grained uneven, sometimes a little conchoidal, or nearly even; its lustre is more or less shining and metallic.

(*Chemical characters.*) Before the blowpipe, the sulphur is driven off, and a globule of silver remains. If slowly heated, the sulphur is dissipated, and the silver appears in filaments variously twisted, or dendritic, like native silver. Hence the opinion, that native silver, when filamentous, may have arisen from a similar decomposition. It is composed of silver 85, sulphur 15. (*KLAPROTH.*) It is a very rich ore.

(*Geological situation.*) This ore is found in metallic veins, which usually traverse primitive or transition rocks. It is associated with other ores of silver, as native silver, sulphuretted antimonial silver, &c. also with the sulphurets of lead and zinc, arsenical and sparry iron. Indeed it is found in almost all silver mines, but never by itself constitutes whole veins.—Its more common gangues are quartz, carbonate of lime, and sulphate of barytes. It is often attached to the surface of its accompanying minerals.

(*Localities.*) These are numerous; but we mention only the mines of Freyberg, &c. in Saxony; of Joachimsthal in Bohemia; of Cornwall; and the numerous veins of silver in Mexico and Peru.

In the *United States*. In *New York*, Columbia County, in Livingston's lead mine. (*SCHAEFFER.*)—In *Connecticut*, it is also said to have been found.

SUBSPECIES 1. CUPREOUS SULPHURET OF SILVER.

Silberkupferglanz. *Stromeyer.*

Its color is between lead gray and iron black, with a tinge of red. Its fracture is more or less conchoidal with a metallic lustre, somewhat shining. Its specific gravity is 6.25.

It contains, according to Stromeyer, silver 52.3, copper 30.5, sulphur 15.8, iron 0.4;=99.. Or, it may be considered as composed of sulphuret of silver 60.65, sulphuret of copper 38.65, sulphuret of iron 0.70.

It is found at Schlangenberg, in Siberia, with pyritous copper.

APPENDIX TO SULPHURET OF SILVER.

SILVER BLACK.

Silberschwarze. *Werner*. Argent noir. *Brochant*. *Brongniart*. Earthy hexahedral Silver glance. *Jameson*. Black sulphuretted Silver. *Aikin*. *Phillips*. Variety of Argent ant. sulf. noir. *Hauy*. Sooty silver ore. *Kirwan*.

Its color is bluish black or very dark lead gray. It is sometimes more or less solid, but is easily broken, and presents a dull, earthy, or uneven fracture. Its streak, however, is shining and metallic. Sometimes it is friable or even pulverulent. It occurs in crusts or in masses, which are frequently cellular or corroded. It often slightly soils the fingers.

(*Chemical characters.*) Before the blowpipe it easily melts, and globules of impure silver may be obtained. It has not been analyzed, but the silver is evidently in variable proportions. It is most probably an alteration of the sulphuret of silver, or of the sulphuretted antimonial silver, both of which it usually accompanies. It may also proceed from the decomposition of muriate of silver.

(*Geological situation and Localities.*) It is sometimes connected with quartz and hornstone, or invests other ores of silver or sulphuret of lead with thin crusts, or fills their cavities. Sometimes also it forms the interior of geodes of muriate of silver.

It is common in the mines of Mexico and Peru. It occurs also in the silver mines of Hungary; at Allemont in France; Freyberg in Saxony; in Cornwall, &c.

SPECIES 5. CUPREOUS SELENIURET OF SILVER.

Eukairite. Berzelius.

Its color is a shining lead gray. It has a granular structure; yields easily to the knife; and the surface thus brought to view has the lustre of silver.

It melts before the blowpipe, exhaling a strong odor, like that of horse radish; a small, gray, metallic globule remains. It contains, according to Berzelius, silver 38.93, *Selenium* 26.00, copper 23.05, foreign substances 8.90; = 96.88. Or it may be considered a compound of seleniuret of silver and seleniuret of copper. When cold water is added to a solution of this ore in boiling nitric acid, a white precipitate of seleniate of silver appears.

It is found in a copper mine at Skrickerum in Smoland, Sweden, associated with carbonate of lime, blackish or dark green serpentine, seleniuret of copper and pyritous copper.

Its name, *Eukairite*, is derived from the Greek, *ευκαιρος*, *opportune*, because it was discovered about the time, that Berzelius completed his examination of the new metal Selenium.

SPECIES 6. SULPHURETTED ANTIMONIAL SILVER.

Argent antimonié sulfuré. *Haüy. Rothgultigerz. Werner. Rothgiltigerz. Hausmann. Red Silver. Kirwan. Jameson. Aikin. Phillips. Argent rouge. Brochant. Brongniart.*

Red silver ore.

The powder of this mineral is always very nearly crimson red, whatever may be the external color of the mass; and hence the name of Red silver ore.* Its streak also is red, with some lustre.

Its external color is sometimes a pure red, sometimes dark cochineal or blood red, which is often strongly tinged with lead gray, or even passes into it, and sometimes it is reddish or grayish black with a metallic lustre. But most of its darker colors are merely superficial, and arise from an alteration in the mineral. Its external lustre is usually considerable.

This ore is brittle, and easily scraped by a knife. Its fracture is uneven, or imperfectly conchoidal with small cavities, and sometimes nearly even. Its structure is imperfectly foliated in the crystallized varieties; and its lustre, which varies from splendent to glimmering, is either metallic or adamantine.—It is usually translucent, often at the edges only, and sometimes nearly transparent; sometimes also it is opaque, though even in this case the centre of the mass is almost always translucent.—It is a conductor of electricity; and its specific gravity lies between 5.20 and 5.68.

Red silver ore is sometimes in grains or small masses; sometimes it forms membranes or invests the exterior of other minerals, or is dendritic, capillary, &c. and very frequently it is crystallized.

This species presents no less, than fourteen secondary forms, all of which are hexaedra prisms, or double six-sided pyramids, frequently modified by truncations and acumination. The primitive form is an obtuse rhomb, whose plane angles are $104^{\circ} 28'$ and $75^{\circ} 32'$. This approaches the primitive form of carbonate of lime, and the secondary forms of both minerals resemble each other.

It is sometimes in regular six-sided prisms.—Sometimes this prism is terminated at each extremity (Pl. IV, fig. 35.) by three faces, standing on alternate lateral edges, but on different edges at each summit; the edges of the summits, and even all the edges of this crystal are subject to truncation.—Another secondary form is a dodecahedron or double six-sided pyramid (Pl. IV, fig. 36.), in which the alternate and least obtuse edges of each pyramid are truncated by hexaedra faces. The single pyramids, sometimes observed, belong to this variety.—It also occurs in crystals, composed of two incomplete, hexaedra pyramids

* Werner has divided Red silver ore into two subspecies, *dunkles* and *lichtes rothgultigerz*, or dark and light red silver ore; and, according to Jameson, the streak of the former is cochineal or brick red, while that of the latter is aurora red.

(Pl. IV, fig. 37.), applied base to base, and truncated near their summits.—The faces of these crystals have usually a strong lustre, but are often striated, and a little convex; the edges and solid angles are commonly rounded or blunted.

(*Chemical characters.*) Before the blowpipe it decrepitates, melts, and exhales a whitish vapor, with an unpleasant odor, arising from antimony or arsenic, and often distinctly resembling that of garlic; it frequently burns with a bluish flame. By continuing the heat, a globule of silver is obtained. When gradually heated, the silver appears in filaments or dendrites. It is composed, according to Klaproth, of silver 60, antimony 19, sulphur 17, oxygen 4. But, according to the analysis of Vauquelin, it contains silver 56.67, antimony 16.13, sulphur 15.07, oxygen 12.13. This chemist supposes the two metals to exist in the state of an oxide, united with sulphur. Proust, on the contrary, believes both to be in a metallic state, and considers this ore a compound of the sulphurets of silver and antimony. Further, according to the chemist last mentioned, the silver in this mineral is sometimes united to antimony only, sometimes to arsenic only, and sometimes to both metals. One specimen, which he analyzed, yielded sulphuret of silver 74.35, sulphuret of arsenic 25.0, sand and oxide of iron 0.65. If this analysis be correct, a new species must be added to the ores of silver.—The iron, which this mineral sometimes contains, without doubt communicates a dark shade to its color.

(*Distinctive characters.*) There are several minerals, which this more or less resembles, viz. the sulphurets of arsenic, mercury, and silver, specular iron, red oxide of copper, and gray copper. But the red sulphuret of arsenic yields an orange yellow powder, and has a less specific gravity.—Sulphuret of mercury has a greater specific gravity, and is entirely volatilized before the blowpipe.—Sulphuret of silver is malleable.—Specular iron is harder, sensibly affects the needle, and its powder is less distinctly red. The red oxide of copper has a less specific gravity, effervesces in nitric acid, and communicates to ammonia a blue color.—Gray copper is harder, and its powder is blackish.

(*Geological situation and Localities.*) This mineral is found in metallic veins, associated with other ores, and occurs in almost all silver mines. It is sometimes disseminated, but never presents large masses. It is associated with other ores of silver, the sulphurets of lead, zinc, arsenic, &c. native arsenic, sparry iron, arsenical cobalt, gray copper, pyritous copper, arsenical iron, and nickel, &c.—Its more common gangues are the carbonate and fluuate of lime, sulphate of barytes, quartz, and hornstone.

Among its numerous localities may be mentioned the Harz, the mines of Freyberg in Saxony, of Guadalcanal in Spain, of Schemnitz, &c. in Hungary, those of Mexico, &c.

SUBSPECIES 1. BRITTLE SULPHURETTED ANTIMONIAL SILVER.

Argent antimonié sulfuré noir. *Haüy*. Sprodglaserz. *Werner*. Brittle Silver-Glance. *Jameson*. Argent rouge aigre. *Brongniart*. Antimoniated silver ore. *Kirwan*. Sprodglanzerz. *Hausmann*. Brittle sulphuretted Silver. *Aikin*. *Phillips*.

Its color is dark lead gray, or a shining grayish black; indeed, when not tarnished, its external lustre is strong and metallic. It is very *brittle*; and, when cut with a knife, its particles fly off with considerable noise. It retains its lustre and color in its streak, but its powder is black, or blackish brown.—Sometimes, however, in the same group of crystals, some give a red, and others a black, powder; thus connecting this subspecies with the common varieties.

Its fracture is uneven or conchoidal, and more or less shining with a metallic lustre. Its specific gravity is between 6.10 and 7.20.

It occurs amorphous, or in membranes, or crystallized in hexaedra prisms, which are sometimes terminated by six-sided pyramids.—Sometimes its crystals are tabular, and intersect each other, forming cells.—It has sometimes a foliated structure.

(*Chemical characters.*) It melts by the blowpipe, but not so easily, as the common variety; its volatile ingredients are dissipated, and a globule of silver, imperfectly malleable, remains. It contains, according to Klaproth, silver 66.50, antimony 10.0, sulphur 12.0, iron 5, copper and arsenic 0.5, earthy substances 1.0; = 95.

(*Geological situation and Localities.*) Like the common or red varieties of this species, with which it is usually associated, it always occurs in metallic veins. Its gangues and accompanying minerals are of course similar to those of the common variety.

It has been found chiefly in Hungary and Saxony.

SPECIES 7. CARBONATE OF SILVER. JAMESON.

Argent carbonaté. *Haüy*. *Brochant*. Luftsaures Silber. *Widenman*. Carbonated Silver. *Aikin*. *Phillips*. Grau silber. *Hausmann*.

The color of this rare mineral varies from gray to grayish black, and its streak has considerable lustre. It has occurred only in amorphous masses, which are easily broken, and whose fracture is uneven or earthy, and glistening with a metallic lustre.

It effervesces in acids for a short time; and is easily reduced by the blowpipe. It contains silver 72.5, carbonic acid 12.0, carbonate of antimony with a little oxide of copper 15.5. (*SELB.*)—It is, perhaps, an alteration of antimonial silver.

(*Locality.*) It is found in the Furstenberg, Suabia. Its gangue is sulphate of barytes, and it is associated with other ores of silver, among which is antimonial silver.

SPECIES 8. MURIATE OF SILVER. PHILLIPS.

Argent muriaté. Haüy. Brongniart. Hornerz. Werner. Corneous silver ore. Kirwan. L'Argent corné ou muriaté. Brochant. Hornsilber. Hausmann. Hexahedral corneous Silver. Jameson. Horn Silver. Aikin.

This mineral has usually the softness of wax. Hence it may be cut with great ease by a knife, which leaves a glossy surface; indeed in most cases it may be impressed by the finger nail. Its usual color is gray, often pearly, or with a tinge of yellow, red, or green, sometimes nearly white, and sometimes even leek green. By exposure to light its color gradually darkens, and becomes violet blue or brownish. Its surface has sometimes a metallic aspect in consequence of decomposition.—It is more or less translucent, in some cases at the edges only. In thin pieces it is often a little flexible, or even malleable. Its specific gravity extends from 4.60 to 4.80.

It is sometimes crystallized in cubes, either perfect, or elongated into parallelopipeds, or truncated on the angles or edges, or in octaedrons, or in dodecaedrons. But more frequently it occurs in thick membranes, flakes, or crusts, sometimes composed of minute crystals, or in small masses reniform, globular, or amorphous. Its masses sometimes consist of prismatic or granular concretions. Its fracture is uneven or conchoidal, and, when recently made, has a resinous lustre, more or less glistening.

(*Chemical characters.*) Muriate of Silver is very fusible, and melts even in the flame of a candle. Before the blowpipe it diffuses the unpleasant odor of muriatic acid, and leaves on the charcoal a globule of silver nearly pure. When moist, it is a little volatile. (*PROUST.*) If this ore be rubbed by a piece of zinc or iron, which has been moistened by the breath, a thin film of metallic silver immediately appears on the surface of the mineral. It contains silver 76.0, muriatic acid 16.4, oxygen 7.6. (*KLAPROTH.*)

It has so little of a metallic aspect, that it would very often pass unobserved, were it not associated with more obvious ores of silver.

SUBSPECIES 1. ARGILLACEOUS MURIATE OF SILVER.

Argent muriaté terreux. Brongniart. Brochant. Erdiges hornerz. Karsten. Earthy corneous Silver ore. Jameson. Buttermilk Silver. Aikin. Phillips. Buttermilcherz of the Germans.

Its color is whitish, greenish white, or pale green, and sometimes bluish gray or brownish at the surface. Its fracture is earthy and dull; it is almost friable.

Before the blowpipe it does not melt; but contracts and agglutinates, while minute globules of silver flow out. It contains silver 24.64, muriatic acid 8.28, clay 67.08, and a little copper. (*KLAPROTH.*)—It has been found at Andreasberg in the Harz, connected with quartz and calcareous spar.

(*Geological situation and Localities of the Species.*) Muriate of Silver is somewhat rare. It is disseminated in other minerals, or invests them with a crust more or less thick. Sometimes it forms geodes, either empty, or lined with crystals of Muriate of Silver, or containing silver black. It occurs in metallic veins, and generally in the upper parts of the vein. Hence it is undoubtedly the most recent of the ores of Silver; sometimes indeed it is connected with fossil remains.

Quartz, sulphate of barytes, and carbonate of lime are usually its gangues; and it is accompanied by brown oxide of iron, native silver, sulphuret of silver, and silver black, sulphuret and carbonate of lead, oxide and carbonate of copper, &c.

Thus at Schlangenberg, in Siberia, it occurs with native silver, oxide and carbonate of copper, carbonate of lead, native gold, &c.—At Allemont, in France, with several ores of silver, oxide of cobalt, &c.—In Peru, it sometimes envelopes masses of native silver, and is accompanied by gray copper, &c. It is considerably abundant in some of the Peruvian and Mexican silver mines; and is sometimes associated with the phosphate and molybdate of lead.

(*Geological remarks on ores of Silver.*) The ores of Silver belong chiefly to primitive rocks; and occur in metallic veins, which traverse granite, gneiss, micaceous and argillaceous slates, greenstone, sienite, hornblende, and porphyry. They have also been observed in veins, which traverse graywacke, compact limestone, secondary slates, &c. but seldom or never in the more recent secondary rocks.

According to Brongniart, those ores of silver, which occur in secondary rocks, are usually the sulphuret of silver, and red silver. It appears, however, that Silver is often mixed with those ores of other metals, which are supposed to belong more particularly to secondary mountains; such as the sulphurets of lead, zinc, antimony, and mercury.

Silver and its ores, in addition to the more common gangues, already mentioned, are sometimes connected with jasper, serpentine, talc, asbestos, &c. Indeed Silver is sometimes intimately mixed with that variety of asbestos, called mountain cork, in the proportion of 15 per cent. and this compound, which is reddish brown, has been regarded as a distinct ore of Silver.

We have already remarked, that all ores, from which Silver is extracted with advantage, are not, strictly speaking, ores of Silver. This is often the case with the sulphurets of lead, zinc, iron, &c. gray copper, arsenical iron, &c. In fact, a large proportion of the Silver of commerce is extracted from argentiferous sulphuret of lead. These

ores, however, though sometimes arranged as ores of Silver, we refer to what appears to be their proper genera.*

(*Silver mines.*) Of these, the following are some of the more important; the silver being extracted from ores of Silver, or from other ores, which contain this metal, or from both.

Spain furnished the ancients with much Silver; but the most important mine, at present, is that of Guadalcanal, in Estramadura. It contains much Red silver in a gangue of carbonate of lime.

The mine of Allemont, in the department of Isère, France, is situated more than 3000 yards above the level of the sea in a micaceous rock, containing hornblende. This rock is traversed in all directions by veins, containing Native silver, Sulphuret of silver, Red silver, &c. These ores are accompanied by the oxide and arseniate of cobalt, nickel, native antimony, &c. and their gangue is usually ferruginous clay, or carbonate of lime. The richest part of the veins is near their surface.

In Germany, are numerous Silver mines in Saxony, Bohemia, Austria, Suabia, &c. In those of Freyberg, Saxony, the veins usually traverse gneiss, and contain Sulphuret of silver, Red silver, &c. native arsenic, sulphuret of lead, gray copper, &c. the last two ores are argentiferous.

The Silver mines of the Harz, and of Sahlberg in Westmania, contain much argentiferous sulphuret of lead.

The mines of Schemnitz, &c. in Hungary—of Schlangenberg, Kollivan, &c. in Siberia, have furnished much Silver, and some of them are still very productive.—The Silver and Gold mines at Schemnitz and Kremnitz in Hungary, according to Bright, are in veins, composed chiefly of feldspar, and traversing a claystone porphyry, which sometimes passes into greenstone.

The mine of Kongsberg, in Norway, has formerly been more productive than at present. Its richest veins traverse nearly vertical beds of hornblende slate, contained in mica slate. These veins embrace different ores of Silver, but chiefly Native silver and Sulphuret of silver, accompanied by several ores of cobalt, and by the carbonate and fluuate of lime, &c.

But the mines of Mexico, Peru, &c. in America, furnish at least ten times as much Silver, as all the mines of the old continent.

The mountain of Potosi, in Peru, is traversed by numerous veins, containing Native silver, Sulphuret of silver, Muriate of silver, and the Brittle sulphuretted antimonial silver. The gangue of the Peru-

* Thus Wismuthisches silber (l'argent bismuthifere) is referred to *argento-bismuthal sulphuret of lead*;—Weissgultigerz (white silver of Jameson, or light and dark gray silver ore of Kirwan) to *argento-antimonial sulphuret of lead*;—Graugultigerz of Klaproth (gray silver ore), Schwartzgultigerz of Werner (black silver ore), and Argent gris, all to *gray copper*; also Gänsekoethiges silber (l'argent merde d'oie) to *argentiferous arseniate of cobalt*.

vian silver is often a very brittle quartz. These veins have been found less rich, as they have been more deeply explored. But richer veins are now known north of Potosi. According to Humboldt, veins of silver in Peru often traverse compact limestone.

The mines of Mexico or New Spain are vastly more productive, than those of Peru. The great value, however, of these mines depends not on the richness, but the abundance of the ore. For, according to Humboldt, 1600 ounces of the ore does not, at a medium, yield more than 3 or 4 ounces of pure silver. The same quantity of ore in some of the Silver mines of Saxony affords from 10 to 15 ounces. The mine of Valenciana, in the district of Guanaxuoto, presents a vein more than 60 yards in width, and at least 600 yards in depth, traversing a mountain of argillaceous slate. This vein is composed of Native silver, Sulphuret of silver, Red silver, a little gold, the sulphurets of lead, &c. quartz, hornstone, &c.

(*Remarks.*) According to Humboldt, the annual product of the American Silver mines is equal in value to $32\frac{1}{2}$ millions of dollars; of which New Spain furnishes about 22 millions, Peru about $5\frac{2}{3}$ millions, Buenos Ayres about $4\frac{1}{2}$ millions, and Chili the remainder. More than three fourths of this silver is extracted from the ore by amalgamation with mercury.

GENUS VI. *MERCURY.*

This metal usually remains fluid, even when exposed to the greatest cold of the atmosphere in temperate regions. It becomes solid at about 40° below the zero on Fahr. and, in this state, is malleable, flexible, and capable of crystallizing in octaedrons. Its boiling point is about 660° .

(*DALTON.*) When pure and fluid, it is still opaque, and nearly silver white with a strong lustre. Its specific gravity is 13.56; that of solid Mercury is 15.61. (*BIDDLE.*)

It may be oxidated by exposure to caloric in contact with air, or even by long agitation in contact with air only; and its oxides are reducible by caloric. It combines with many of the metals, producing amalgams, which are either soft, or solid and brittle, according to the proportions employed.

The existence of Mercury, even in small quantities, in any of its ores, may be ascertained by mingling the ore with iron filings, and heating this mixture to redness under any cold body, as a plate of polished copper; the mercury is volatilized, and condensed in minute globules on the plate.

(*Uses.*) The uses of this metal are numerous and important in Natural Philosophy, Chemistry, the Arts, and Medicine. Immense quantities are employed in extracting native silver and gold from their gangues by the process of amalgamation. (See remarks at the close of Sulphuret of Mercury.)

SPECIES 1. NATIVE MERCURY. KIRWAN.

Gediegen Quecksilber. *Werner. Hausmann. Mercure natif. Haüy. Brongniart. Brochant. Fluid Native Mercury. Jameson. Native Quicksilver. Aikin. Phillips.*

No one can mistake this metal in its native state. In color, lustre, fluidity, &c. it does not sensibly differ from the pure metal, already described. It occurs in small globules, disseminated in other minerals. These globules are but feebly united to their gangue, and may be liberated by striking or heating the substance, which embraces them.

Native Mercury is generally pure, and may be entirely volatilized by the blowpipe; but it sometimes contains a little silver, which diminishes its fluidity.

(*Geological situation and Localities.*) It is found in almost all those mines, which yield the Sulphuret of Mercury, in which it is often disseminated, or appears at its surface. It is also interspersed through those minerals, which accompany the Sulphuret, such as argillaceous slate, sandstone, compact limestone, clay, &c. Indeed it sometimes flows through fissures in these minerals, and collects in their cavities. It has also been observed in veins traversing primitive rocks.—It is, however, never abundant; and its localities are those of the Sulphuret of mercury.

In the *United States*; it has been found in *Kentucky*, in small globules in a mass, which also appears to contain some native amalgam. (*HARDEN.*)

SPECIES 2. ARGENTAL MERCURY.

Mercure argental. *Haüy. Brongniart. Naturliches Amalgam. Werner. Native Amalgam. Jameson. Phillips. L'Amalgame natif. Brochant. Amalgam. Hausmann. Silver Amalgam. Aikin.*

This native amalgam is more or less solid and brittle, according to the proportion of silver, which it contains. Some varieties, however, are but imperfectly solid; or may perhaps be viewed as a solid amalgam, mingled with native mercury.

Its color varies from tin to silver white. When rubbed warm on copper or gold, it leaves a metallic white trace. Its fracture is imperfectly conchoidal or uneven, and more or less shining with a metallic lustre. Its specific gravity is about 10.5.

It occurs in plates or membranes, or in small globular or amorphous masses, and is also susceptible of crystallizing. Its crystals are regular octaedrons with truncated edges, or dodecaedrons with rhombic faces. This dodecaedron has sometimes its edges and four of its solid angles truncated (Pl. IV, fig. 38.), thus giving a solid with twenty eight faces; indeed, according to Cordier, the truncations are sometimes so numerous, that the crystal presents 122 faces.

(*Chemical characters.*) Before the blowpipe the mercury evaporates, leaving a globule of silver. When crystallized, it contains mercury 72.5, silver 27.5. (*CORDIER.*) In other cases the proportions are variable.

Its want of ductility and its action on a plate of copper sufficiently distinguish it from native silver.

(*Geological situation.*) This ore occurs in mines of the Sulphuret of mercury on the surface of other minerals, or disseminated in them. According to De Born, it is most frequently found in those veins of mercury, which are intersected by veins of silver, or in which the ores of the two metals are intermingled. Its gangue is sometimes lithomarge, or a ferruginous clay variously colored. It is a rare mineral.

SPECIES 3. SULPHURET OF MERCURY.

Mercure sulfuré. Haüy. Brongniart. Zinnober. Hausmann. Cinnabar. Jameson. Aikin. Phillips.

Cinnabar.

This species occurs much more abundantly, than any of the other ores of mercury, and is hence peculiarly interesting and important.

Its color always presents some shade of red, which sometimes passes to brown by foreign mixture; sometimes also the surface becomes dark metallic gray by a chemical change. But its powder and streak are scarlet or cochineal red. It is easily scraped by a knife, unless intermixed with harder bodies; and its specific gravity generally lies between 6.7 and 8.2. When rubbed on white paper, it usually leaves a red trace.

Sulphuret of mercury is found amorphous, or under some imitative form, or crystallized. The primitive form is an acute rhomb, the incidence of whose faces is $71^{\circ} 48'$ and $108^{\circ} 12'$. This rhomb is liable to great alterations by additional faces; and hence some of the secondary forms of this species have very little resemblance to the primitive, and are described as octaedrons, &c.—Among its secondary forms are a regular six-sided prism, sometimes terminated by three-sided summits, whose faces correspond to three of the lateral planes;—and an acute rhomb, whose summits are truncated. The crystal (Pl. IV, fig. 39.), when carefully examined, is found to be a short hexaedral prism, terminated at each extremity by six faces, or rather by three *pairs* of faces, which correspond to alternate lateral planes; the faces at one extremity also alternate with those at the other, and the lateral faces are sometimes rounded.—The crystals, sometimes tabular, are usually small with a high lustre, and often much grouped.

(*Chemical characters.*) When pure, it is entirely volatilized by the blowpipe, with a bluish flame, and a smoke having a feeble odor of sulphur. It is essentially composed of sulphur and mercury only. (See analyses under the varieties.)

(*Distinctive characters.*) From other red ores, as red silver, red oxide of copper, chromate of lead, and red sulphuret of arsenic, it is distinguished by being entirely volatile before the blowpipe, or by not yielding a metallic globule, nor the well known odor of garlic.

Var. 1. COMMON SULPHURET OF MERCURY.* (Common Cinnabar.) Its color is usually cochineal red, sometimes carmine or brownish red, or nearly lead gray, but its streak is a shining scarlet red. It is generally opaque, or translucent at the edges only; the crystals, however, are sometimes semitransparent.

It is easily broken, and its fracture is uneven, and sometimes even or conchoidal; its lustre is variable, either shining or only glimmering, and often slightly metallic.—When crystallized, its structure is foliated, and its specific gravity about 10.2, which, in impure specimens, falls to 6.90 or lower.

This variety not only presents the crystalline forms already mentioned, but is found also in laminated, or granular masses, which are sometimes almost compact, or is reniform, dendritic, in plates, &c.—in fine, it is sometimes in a loose state, and has then been called *flowers of Cinnabar*, or native vermillion.

It appears to be composed of mercury 85, sulphur 15. (*KLAPROTH.*)—Most of the Mercury of commerce is extracted from this variety.

2. FIBROUS SULPHURET OF MERCURY.† (Fibrous Cinnabar.) Its color is scarlet red, often lively, and sometimes with a tinge of yellow. Its structure is more or less distinctly fibrous, and its lustre, though feeble, is often silky; its cross fracture is earthy and dull. It is opaque, very easily broken, and soils the fingers a little, especially when wet.—It occurs amorphous, or in flakes, and sometimes invests other minerals, or is disseminated.

This variety is rare; and has hitherto been found chiefly at Wolfstein, &c. in the Palatinate, and accompanies the common variety.

3. COMPACT SULPHURET OF MERCURY OR CINNABAR.‡ Its color is reddish brown, or dark cochineal red with a mixture of lead gray. Its streak, however, is a dark red, and has some lustre. It is opaque, yields to the knife, and is easily broken. It occurs in compact masses, whose fracture is even, or sometimes fine grained uneven, with a moderate lustre somewhat metallic. Its specific gravity is between 7.1 and 7.3.

* Mercure sulfuré compact, granulaire, &c. *Hauy. Brongniart.* Dunkel rother Zinnober. *Werner.* Dark red Cinnabar. *Jameson.* Le Cinnabre commun. *Brochant.* Variety of Native Cinnabar. *Kirwan.* Dunkler Zinnober. *Hausmann.*

† Mercure sulfuré fibreux, *Hauy. Brongniart.* Hockrother Zinnober. *Werner.* Bright red Cinnabar. *Jameson.* Le Cinnabre fibreux. *Brochant.* Fibrous Cinnabar. *Aikin.* Lichter Zinnober. *Hausmann.*

‡ Mercure sulfuré bituminifere compact. *Hauy.* Mercure sulfuré hepaticque. *Brongniart.* Compact hepatic Cinnabar. *Jameson.* Dichtes Quecksilber Lebererz. *Werner.* Dichtes Lebererz. *Hausmann.* Hepatic Cinnabar. *Aikin. Phillips.* Hepatic mercurial ore. *Kirwan.* Le Mercure hepaticque. *Brochant.*

It is less pure than the preceding varieties. A specimen from Idria yielded Klaproth mercury 81.8, sulphur 13.75, carbon 2.3, silex 0.63, alumine 0.55, oxide of iron 0.2, of copper 0.02 ;= 99.27.

4. SLATY SULPHURET OF MERCURY OR CINNABAR.* Its color, like that of the compact variety, is reddish brown, sometimes with a tinge of violet, and sometimes it is almost iron black. Its powder is nearly cochineal red. Its structure is slaty ; and the layers, usually thick, and a little curved, possess considerable lustre, somewhat metallic. It is easily broken, and the cross fracture is even, and nearly dull.

When in globular, or concentric lamellar concretions, it is sometimes called *Korallenerz*.

This and the compact variety constitute a large proportion of the mercurial ore in the mines of Idria, where it is accompanied by the common variety, &c.

APPENDIX TO SULPHURET OF MERCURY.

BITUMINOUS CINNABAR.

The compact and slaty varieties of this species have been considered a Bituminous Sulphuret of Mercury. But the analysis, given under the compact variety, shows that this opinion is incorrect. (See also the memoir of M. Payssé, Director of the mines of Idria, in the *Tableau Meth. of Lucas*, tom. ii, p. 515.)

Bituminous Cinnabar appears to be a mixture of some of the preceding varieties with coal or bituminous shale.—Its color is brown, with shades of red, black, or gray. It occurs in small masses, which sometimes present a slaty or granular structure ; and sometimes their fracture is conchoidal. Its specific gravity is moderate.

It burns with a lively flame, exhaling a bituminous odor, and white mercurial vapors, but without any sensible odor of sulphur. When distilled, it leaves a porous, coaly residue, forming about $\frac{1}{5}$ of the mass. The bitumen is usually in the proportion of $\frac{2}{5}$.—It yields from 4 to 40 pounds of mercury per quintal.

It accompanies the compact and slaty varieties at Idria, but is not abundant.

(*Geological situation of Sulphuret of Mercury.*) We have already remarked, that this is the only species of the ores of mercury, which exists in any considerable quantity. The other three species, whenever they occur, are almost always connected with this.

Sulphuret of Mercury is rarely found in primitive rocks, and then almost always in small quantities. There is, however, in the republic of Venice a mine of this Sulphuret in granite, in sufficient quantity to

* Mercure sulfuré bituminifère feuilleté. *Hauy*. Schieferiges Lebererz. *Werner*. Slaty mercurial Hepatic ore. *Jameson*. Korniges Lebererz. *Hausmann*.

be explored. (*SPALLANZANI*.) It has also been observed in argillaceous and chlorite slates, and in veins, traversing trap and feldspar porphyries.

But in secondary rocks this ore occurs in considerable quantities with bituminous shale, sandstone, compact limestone, ferruginous clay, &c. and is thus connected with coal formations. Mercury is of course one of the more recent metals.

Sulphuret of Mercury occurs in beds, or large irregular masses, and sometimes in veins; the general structure of the mass is sometimes cavernous. It is associated with the sulphurets of lead and zinc, oxide of iron, gray copper, quartz, calcareous spar, &c.

(*Localities.*) The mines, which furnish this ore, are by no means common; and many countries, as Sweden, Great Britain, Russia, &c. scarcely contain this mineral. Spain, Germany, Mexico, New Grenada, and Peru possess the most important mines.

In Spain, at *Almaden*, near Cordova, these mines are in a mountain of argillaceous slate or shale. The Cinnabar, mixed with quartz, is found in beds or veins of sandstone or breccia, which traverse the mountain, and contain fragments of limestone and shale. These mines have been worked more than 2000 years.

In Germany, at *Idria*, in Carniola, the mines are situated partly in gray compact limestone, and partly in shale, penetrated with the Sulphuret of Mercury. The ore is chiefly the compact and slaty varieties; and is accompanied by the sulphuret of iron, which contains both the Sulphuret of Mercury, and native mercury. These mines also contain a kind of lignite, or coal, which embraces more or less of this Sulphuret.

Numerous mines of Mercury are explored in the Lower Palatinate and in the Duchy of Deux Ponts, as at Wolfstein, Potsberg, Landsberg, &c. The mountains are here composed of sandstone, argillaceous slate, ferruginous clay, &c. and the Sulphuret of Mercury, accompanied by argental and native mercury, occurs in scattered masses, or irregular veins; its gangues are lithomarge, clay, hematite and ochreous oxide of iron.—Near Munster Appel, the slate embraces fossil fish, spotted with Sulphuret of Mercury.

In Mexico, at Durasno, Cinnabar mixed with native mercury forms a horizontal bed, resting on porphyry, and covered by shale, containing coal.—The vein of San Juan de la Chica, from 6 to 20 feet wide, traverses pitchstone porphyry.—In New Grenada, near Azogue, it occurs in an argillaceous sandstone, which also contains bitumen and bituminous wood.—In Peru, near Huancavelica, in the Mount of Santa Barbara 14,506 feet above the sea, Cinnabar occurs both in beds and veins. At the great mine of Santa Barbara, the Cinnabar is found in a bed of sandstone, embraced in carbonate of lime, of which the mountain

appears to be chiefly composed.—Near Sillacasa, it occurs in veins, traversing limestone; and from these veins, which often contain chalcidony, most of the mercury of Peru is at present obtained.

In the *United States*. In the *Michigan Territory* and *Ohio*, more particularly on the shores of Lakes Michigan, Huron, St. Clair, Detroit river, and Lake Erie to the mouth of Vermillion river. It occurs in the soil in the form of a black and red sand, but is usually more abundant in banks of fine ferruginous clay. Near the mouth of Vermillion river, it is in the form of a very fine, red powder, or in grains and small masses, disseminated in clay. It yields by distillation about 60 per cent. of Mercury. (*STICKNER* in Silliman's Journ. vol. i and ii.)

(*Remarks.*) Mercury is obtained chiefly by the distillation of its Sulphuret; iron filings or lime being added to detain the sulphur. According to Humboldt, the quantity of Mercury, annually employed in the American mines in the extraction of silver from its ores by amalgamation, is about 25,000 quintals. Of this, the greater part has recently been furnished by the mines of Almaden and Idria. In 1802, the mines of Almaden yielded more than 20,000 quintals. The mercury mines of Huancavelica in Peru, which formerly produced 10,000 quintals annually, do not at present yield 4000. The vermilion of commerce, which is a sulphuret of mercury, is, in general, artificially prepared.

SPECIES 4. MURIATE OF MERCURY.

Mercure muriaté. Haüy. Brongniart. Brochant. Quecksilber Hörnerz. Werner. Mercury mineralized by the vitriolic and marine acids. Kirwan. Pyramidal corneous Mercury. Jameson. Horn Quecksilber. Hausmann. Horn Quicksilver. Aikin. Phillips.

The color of this native mercurial salt is usually gray, sometimes pearl gray, or nearly white, sometimes shaded with yellow or green, and even passes into greenish yellow. It is usually translucent, at least at the edges. It is brittle, and may be easily scraped by a knife.

Muriate of mercury most frequently occurs in crusts, which are often reniform or tuberos, and line the cavities of its gangue. Within these cavities it also appears in shining crystals, so minute and grouped, that it is difficult to determine their form. Sometimes, however, they are prisms, having four hexagonal sides, and terminated by four rhombic faces, placed on the lateral edges.—Sometimes the faces of the pyramids correspond to the lateral planes.

(*Chemical characters.*) Before the blowpipe it is entirely volatilized without decomposition. A specimen yielded Klaproth mercury 76.0, muriatic acid 16.4, sulphuric acid 7.6. In some specimens the sulphuric is said to exceed the muriatic acid in quantity. According to Fourcroy, the Muriate of mercury is in the state of corrosive sublimate. It is soluble in water, and yields, on the addition of lime-water, an orange colored precipitate.

It does not, like muriate of silver, ever possess the softness of wax, nor leave a metallic globule, when heated.

(*Localities.*) This ore is rare. In the mercury mines of Deux Ponts, it occurs in the cavities of a ferruginous clay or sandstone, or of argillaceous oxide of iron, accompanied by other ores of mercury, gray copper, &c.—At Idria, it occurs in cavities of indurated clay with crystallized cinnabar, &c. and sometimes in shale.

GENUS VII. *COPPER.*

This mineral is less malleable, than gold, silver, or platina. Its tenacity, or the strength of its wire, is greater than that of any metal, excepting iron. In hardness it is exceeded by iron and platina; but it is harder and more elastic than silver, and is the most sonorous of the metals. Its color is a pale red, tinged with yellow. Its taste is styptic, and nauseous. Its specific gravity varies according to the operations, it has undergone; a mean of four experiments on Swedish and British copper by Hatchett gives 8.77.

Copper melts at about 27° W. It becomes oxidated by air, but not by water, when air is excluded. Its oxides are soluble in ammonia, to which they communicate a fine azure blue color. Even the pure metal becomes oxidated, and is dissolved by ammonia in open vessels, producing the same blue color. Borax is colored green by the oxide of Copper. The two last mentioned characters are very useful tests of the presence of Copper, or rather of its oxide. When dissolved in acids, it may be precipitated in a metallic state by a plate of polished iron.

(*Uses.*) The uses of Copper, either when pure, or when alloyed, are numerous, and in general well known. Thus, when alloyed with zinc, it forms *brass*, *pinchbeck*, &c. Copper and tin, in different proportions, are the principal ingredients in *bronze*, *bell-metal*, *speculum-metal*, &c. The oxides of Copper are employed to give a green color to the enamel on porcelain, and its salts enter into the composition of several pigments, as *verditer*, *Brunswick green*, &c. But it ought to be remembered, that the oxides and salts of Copper are violent poisons; and, of course, that vessels, constructed of Copper, should never be employed for culinary purposes. Even when the Copper is alloyed with zinc, thus forming brass, or when coated with tin, the danger is very far from being removed, and *fatal* accidents have sometimes resulted from the use of vessels, composed of brass or tinned Copper.—An ancient Peruvian chisel yielded Vauquelin Copper 94, tin 6.

SPECIES 1. NATIVE COPPER. KIRWAN.

Gediegen Kupfer, *Werner*. *Hausmann*. Cuivre natif, *Hauy*. *Brongniart*. *Brochant*. Octahedral Copper. *Jameson*. Native Copper. *Aikin*. *Phillips*.

Native Copper presents nearly all the characters of pure Copper, already described. Although its true color is, in fact, the same, its

surface is often tarnished with shades of brown, black, yellow, &c. but its streak is splendid and metallic. Its fracture is hackly, and has a metallic lustre. Its specific gravity varies from 7.60 to 8.78.

Native Copper is often crystallized. Its forms are a cube, which may be truncated on the angles, or edges, or on both; an octaedron, sometimes truncated on the edges or angles; a rhombic dodecaedron, &c. The crystals are usually small and much grouped.—It also presents certain imitative forms, being dendritic, branched, reticulated, filiform, or in tufts like moss, or in dentiform, reniform, or botryoidal concretions. In fine, it sometimes occurs in laminæ or plates, and in grains, or amorphous masses.

Its malleability distinguishes it from arsenical nickel, and other ores, which it may resemble in color.

(*Geological situation.*) Native Copper is found chiefly in primitive rocks, through which it is sometimes disseminated, or more frequently it enters into the composition of metallic veins, which traverse these rocks. It is thus connected with granite, gneiss, micaceous and argillaceous slates, granular limestone, chlorite slate, serpentine, porphyry, &c. It also occurs in transition and secondary rocks. It accompanies other ores of copper, as the red oxide, the carbonate and sulphuret of copper, pyritous and gray copper, also the red and brown oxides of iron, oxide of tin, &c.—Its usual gangues are quartz, carbonate of lime, and sulphate of barytes. At Oberstein, it occurs in prehnite; and in the Faroe islands, it accompanies zeolite.

Native Copper is not rare, nor is it found in sufficient quantity to be explored by itself. It sometimes occurs in loose, insulated masses of considerable size.

(*Localities.*) Some of its more important localities are the mines of Tourinski on the eastern side of the Uralian mountains, and of Schlangenberg in Siberia; of Fahlun in Sweden; and of Cornwall and Anglesea in England. In Cornwall, its veins traverse granite and argillite.—In Brazil, near Cachoeira, a loose mass, weighing 2,600 pounds, has been found; its surface is rough, and invested in part with malachite. (*VANDILLI.*)

In the *United States.* In *Illinois*, Monroe County, in the Highlands back of Harrisonville, where one mass weighed 7 pounds—also on Big Maddie river. (*SCHOOLCRAFT.*)—Also in the *North West Territory*, about 30 miles South from Lake Superior, on the west bank of the river Ontonagon, has been found a very large mass of Native Copper, weighing by estimation about 2,200 pounds. It is connected with serpentine, in which small masses and grains of Native Copper are disseminated; and it lies near the water's edge, at the foot of an elevated bank of alluvion—also at the portage across

Keweena point, Native Copper, from the size of grains to that of masses weighing 2 pounds, is disseminated in rolled pebbles—also near Chegoimegon point, 80 miles W. from the Ontonagon, a mass, weighing 28 pounds, has been found. (*SCHOOLCRAFT.*) This copper has a compact texture, is malleable, and not alloyed with other metals. (Eustis' letter to Prof. Mitchill.)—In *Virginia*, in Orange County. (*CONRAD.*)—In *Maryland*, Washington County, on the Blue Ridge. (*HARDEN.*)—Also 15 miles from Fredericktown, with sulphuret of copper. (*COOPER.*)—In *Pennsylvania*, in Hamilton Ban, Adams County. (*CONRAD.*)—Also at Morgantown in Berk's County, and at Pottsgrove in Montgomery County. (*COOPER.*)—At Perkiomen lead mine, it occurs both massive and dendritic. (*WETHERILL.*)—In *New Jersey*, at Woodbridge, in grains and plates disseminated in a blackish, friable rock. (Med. Repos.)—Also in Schuyler's mines.—In *Connecticut*, at Bristol, with the red oxide of copper, in a small vein; indeed Native Copper, the red oxide of copper, and pyritous copper have been found through an extent from Bristol and Newhaven in Connecticut to Deerfield in Massachusetts. (*GIBBS.*)—Also near New Haven, on the Hamden hills, a mass of Native Copper, weighing about 90 pounds, was found, many years since, adhering in part to the surface of the rock, on which it rested, and even penetrating its fissures—more recently has been found, 12 miles from New Haven, and $\frac{1}{2}$ mile W. from Hartford turnpike, in alluvial soil, a mass of Native Copper, weighing about 6 pounds, and exhibiting the rudiments of large octaedra crystals of copper on its surface, which is partly incrustated by the green carbonate of copper; its cavities contain the red oxide of copper. The rocks in the vicinity are secondary greenstone and red sandstone. (*SILLIMAN.*)

SPECIES 2. SULPHURET OF COPPER.

Cuivre sulfuré. *Haüy. Brongniart.* Kupferglas. *Werner.* Rhomboidal Copper-Glance. *Jameson.* Kupferglanz. *Hausmann.* Le Cuivre vitreux. *Brochant.* Glance Copper. *Aikin.* Vitreous Copper. *Kirwan. Phillips.*

Its true color is dark lead gray or iron black; but its surface is often tarnished, either black, or with irised colors. Sometimes also it is reddish from an intermixture of the red oxide of copper. Its streak is metallic and shining; and its fine powder is blackish.

It easily breaks, and, when cut with a knife, it separates into grains, and not into slices, like the sulphuret of silver. Its specific gravity varies from 4.12 to 5.80. Its fracture is more or less conchoidal, and sometimes even, or fine grained uneven, with a glistening lustre, usually metallic, but in some cases very feeble.—Some varieties present a foliated* structure.

* Foliated Copper-glance. *Jameson.*

Sulphuret of copper most frequently exists in compact, amorphous masses; and but rarely occurs in regular crystals. Its forms are a short, regular six-sided prism, sometimes truncated on its terminal edges, or otherwise modified, and a double six-sided pyramid, whose summits are sometimes truncated, or replaced by four-sided pyramids. Its secondary forms, of which Haüy mentions five, are derived from the hexaedral prism.

(*Chemical characters.*) It is very easily fusible, often by the flame of a candle only. When melted on charcoal by the blowpipe, it yields an odor of sulphur, and is reduced into a grayish metallic globule, contaminated with iron, and often magnetic. It tinges borax green, and ammonia blue. A specimen from Siberia yielded Klaproth copper 78.5, sulphur 18.5, iron 2.25; = 99.25. In another from England Chenevix found copper 84, sulphur 12, iron 4.—It is of course a rich and valuable ore of copper.

(*Distinctive characters.*) This mineral somewhat resembles gray copper; but the latter usually decrepitates, when suddenly heated, is harder, and, when cut with a knife, the particles fly off.—It is easily distinguished from sulphuret of silver.

This ore sometimes presents a *variegated* aspect, and seems to have undergone an alteration similar to that, by which pyritous copper appears to be converted into variegated pyritous copper.—Sometimes indeed it is intimately mixed with pyritous copper.

*Var. 1. PSEUDOMORPHOUS SULPHURET OF COPPER.** This remarkable variety occurs in small, oval, flattened masses, with blackish projecting scales, and resembles the little cones of the pine tree, or ears of corn much compressed. Indeed these masses are by many supposed to arise from the penetration of these vegetable substances by Sulphuret of copper. Some of them, however, appear to be an aggregation of minute crystals.—They are found at Frankenberg, in Hessa, in veins, which traverse primitive rocks; and are sometimes covered with a film of native silver.

(*Geological situation and Localities.*) Sulphuret of copper, either in beds or veins, occurs most frequently in primitive rocks, associated with malachite, the red oxide, and other ores of copper, oxide of iron, quartz, calcareous spar, &c. With the red oxide of copper and pyritous copper it sometimes forms large veins.—Sometimes it occurs in amygdaloid, sandstone, and other secondary rocks.

Siberia, Sweden, Hungary, and England contain some of its most important mines. The best crystals come from Cornwall; but this ore is most abundant in the Uralian mountains.

In the *United States*. In *Maryland*, near Baltimore, and Libertytown.—In *Pennsylvania*, 2 miles N. from Nicholson's Gap, on the Blue

* Cuivre sulfuré pseudomorphique. Haüy. Cuivre spiciforme. Brongniart. Also Hessian Corn-ears.

Ridge. (*HARDEN.*)—In *New Jersey*, it occurs in a red sandstone formation, accompanied with the oxide and carbonate of copper. (*GIBBS.*) Schuyler's mines have not been worked for several years, although the ore is considerably abundant; some shafts were sunk 300 feet deep. (*PIERCE & TORREY.*)—In *Connecticut*, near New Haven, Simsbury, &c.

APPENDIX TO SULPHURET OF COPPER.

BLACK COPPER. JAMESON.

Kupferschwarze. *Werner. Hausmann. Black Copper. Kirwan. Aikin. Phillips. Le Cuivre noir. Brochant.*

It has a bluish or brownish black color, and usually occurs in dull, friable masses. Before the blowpipe it exhales the odor of sulphur, melts into a slag, and tinges borax green.

It is associated with other ores of copper, more particularly the Sulphuret of Copper, gray and pyritous copper, and is, without doubt, merely an alteration of some of these ores. It is sometimes disseminated in them, and sometimes invests their surface.

SPECIES 3. PYRITOUS COPPER.

Cuivre pyriteux. *Haüy. Brongniart. Kupferkies. Werner. Hausmann. Octahedral Copper Pyrites. Jameson. La Pyrite cuivreuse. Brochant. Yellow copper. Kirwan. Aikin. Copper Pyrites. Phillips.*

When this mineral is recently broken, its color is brass yellow, sometimes inclining to gold yellow, and sometimes strongly tinged with gray, depending probably on the relative proportions of copper and iron. Its surface is very often tarnished, sometimes with shades of brown, black, &c. and frequently the tarnish is very richly and beautifully *irised*, or pavonine, &c.

This ore is brittle, easily yields to a knife, seldom gives sparks with steel, and then with difficulty. Its fracture is commonly uneven, sometimes more or less conchoidal, or nearly even; its lustre is metallic and usually more or less shining, but variable. Its specific gravity usually lies between 4.08 and 4.34.

Pyritous Copper occurs in amorphous masses of various sizes; also in plates, or dendrites, and sometimes in stalactites, or in reniform, tuberos, mammillary, and botryoidal concretions. The surface of the concretions is often a bronze yellow, strongly tinged with a metallic gray, and presents numerous little cavities.—The mammillary and botryoidal concretions are generally harder, than the crystallized and amorphous varieties.

Pyritous Copper also occurs in small crystals, which are seldom well defined. It sometimes presents its primitive form, a regular tetraedron, which may be truncated on its edges, or angles, or on both; and is sometimes bevelled on all its edges.—Another form is a

dodecaedron (Pl. IV, fig. 40.), formed by raising a low three-sided pyramid on each face of the tetraedron.—It occurs also in cubes, and in octaedrons, whose edges and angles are sometimes truncated.—It sometimes presents hemitrope crystals.—The crystallized varieties sometimes possess a foliated structure, and often exhibit a high lustre.

(*Chemical characters.*) Before the blowpipe it decrepitates, yields the odor of sulphur, and melts into a black globule, which, with some difficulty, may generally be made to assume the metallic lustre of copper. It tinges borax green. Pyritous copper is not composed of copper and sulphur only; it always contains iron, but in proportions extremely variable. Gueniveau obtained copper 30.5, iron 33.0, sulphur 35.0;=98.5. A mammillary specimen yielded Chenevix copper 30, iron 53, sulphur 12, silex 5. Proust considers this ore a compound of the sulphurets of copper and iron; and the iron is, in fact, sometimes so abundant, that it is difficult to draw a limit between this species and the sulphuret of iron. There does not, however, appear to be sufficient sulphur to produce the two sulphurets; for, if all the sulphur were combined with the iron, it would not, in general, be more than sufficient to produce that compound, which constitutes the common sulphuret of iron.

It sometimes contains a little gold or silver. Moist air has less effect on this ore, than on the sulphuret of iron; sometimes, however, decomposition takes place, and sulphate of copper is produced.

(*Distinctive characters.*) This mineral much resembles sulphuret of iron or iron pyrites; but the latter is harder and almost always gives sparks with steel; its prevailing color is bronze yellow, in which the yellow is much mixed with gray, whereas the prevailing color of Pyritous Copper is brass yellow. Sulphuret of iron seldom, if ever, presents those beautiful tarnishes, which so often appear on this species. In fine, sulphuret of iron never crystallizes in tetraedrons.—From native gold, Pyritous Copper is distinguished by its want of malleability.

(*Geological situation.*) This is the most common and abundant ore of copper. It occurs in veins, which are often very wide, and in beds, which are sometimes very thick. It is found chiefly in primitive and transition rocks, but sometimes in those, which are secondary. It is associated with other ores of copper, sparry and magnetic iron, oxide of tin, sulphurets of lead and iron, quartz, &c.

(*Localities.*) Its most important foreign localities will be mentioned at the close of this genus.

In the *United States*. In *Pennsylvania*, it is found in Montgomery County, at Perkiomen lead mine; (*WISTER.*)—also near Chester in Delaware County, with sulphuret of molybdena. (*CONRAD.*)—In *New York*, near Fort Lee, on the Hudson, in the beds of streams, proceeding from the neighboring hills; it occurs in quartz or in a breccia with

fibrous carbonate of copper and micaceous oxide of iron. (*PIERCE & TORREY*.)—In *Connecticut*, in the greenstone mountains, which extend northerly from New Haven, through Cheshire, Simsbury, &c. with native copper and the red oxide of copper. At Cheshire, is found a singular compound of Pyritous Copper, green carbonate of copper, quartz, carbonate of lime, sulphate of barytes, and sandstone, all blended in the same mass, but perfectly distinct. Numerous pits and galleries have been excavated in these hills to obtain copper, but with little success. The shaft and galleries of an ancient copper mine at Simsbury is at present a State prison. (*SILLIMAN*.)—In *Massachusetts*, in the lead mine in Southampton, Hampshire County, the copper is either disseminated, or exists in a vein.—Also at Woburn, with magnetic iron, in a vein traversing greenstone—and at Cambridge in rolled masses of quartz. (*J. F. & S. L. DANA*.)—Also at Brighton, in quartz accompanying amygdaloid. (*GODON*.)—In *Maine*, at Brunswick, with sulphuret of molybdena in granite.

(*Remarks.*) A large proportion of the Copper, employed in commerce, is extracted from Pyritous Copper, which, however, yields only from 2 to 20 and sometimes 36 per cent. The softer varieties are richest in copper. Its sulphur is sometimes collected by sublimation

SUBSPECIES 1. VARIEGATED PYRITOUS COPPER.

Cuivre pyriteux panaché. *Brongniart*. Buntkupfererz. *Werner*. Variegated Copper. *Jameson*.
Cuivre pyriteux hepatic. *Hauy*. Purple Copper. *Kirwan*. *Aikin*. *Phillips*. La Mine de
Cuivre panachée. *Brochant*. Bunter Kupferkies. *Hausmann*.

This ore is characterized chiefly by its lively and *variegated* colors. When recently broken, its color is reddish brown with a shade of yellow; but it quickly tarnishes and presents various and intermingled shades of blue, violet, purple, red, brown, reddish yellow, and green. Its streak and powder are usually reddish.

It is less hard, than the common Pyritous Copper, and is sometimes so brittle, that it yields to the finger nail. Its fracture is conchoidal with small cavities, or uneven, with a shining metallic lustre, which diminishes with the tarnishing. Its specific gravity is usually between 4.95 and 5.46.—It occurs amorphous, or in plates, which are sometimes hexangular; indeed its masses sometimes separate into plates. It has also been observed in cubes, sometimes truncated on the solid angles.

(*Chemical characters.*) It effervesces with nitric acid; and melts before the blowpipe, on charcoal, yielding a metallic globule, which is magnetic. A specimen from Silesia yielded Klaproth copper 58, iron 18, sulphur 19, oxygen 5. If this analysis be correct, it differs from Pyritous Copper chiefly by containing oxygen; and is perhaps an alteration of the common Pyritous Copper. Indeed *Hauy* remarks, that it is not rare to find specimens, in which the gradual alteration is perceptible.

Its greater specific gravity may often assist to distinguish it from the tarnished specimens of Pyritous Copper.

(*Geological situation and Localities.*) It occurs in metallic veins, or more often in beds, and most frequently in primitive rocks. It is associated with other ores of copper, more particularly Pyritous Copper and sulphuret of copper.

It is found in the mines of Arendal, Cornwall, the Harz, &c.

It is less abundant than Pyritous Copper; but is smelted, and sometimes yields more than 50 per cent.

SPECIES 4. GRAY COPPER. AIKIN.

Cuivre gris. Haüy. Brongniart. Fahlerz. Werner. Phillips. Gray Copper ore. Kirwan. Le Cuivre gris. Brochant. Tetrahedral Copper Pyrites. Jameson.

The color of this ore is steel gray of different shades, sometimes inclining to lead gray, and sometimes to iron black, and is liable to tarnish. Its powder is blackish sometimes with a shade of red.

It is easily broken, and its fracture is usually uneven, but sometimes a little conchoidal or nearly even; its lustre is metallic and somewhat shining. Its specific gravity commonly lies between 4.44 and 4.96. Its hardness is about the same as that of pyritous copper.

It is found both amorphous, and in regular crystals. The primitive form, under which it sometimes occurs, is a regular tetraedron, of which Haüy has described no less than twelve modifications, but the nucleus or primitive form is very seldom entirely concealed. Sometimes its solid angles are truncated;—and sometimes each solid angle is replaced by three faces, or even by four, or six faces.—Sometimes the edges of this tetraedron are truncated or bevelled;—and sometimes two of the preceding modifications are combined in the same crystal.—Another secondary form is a dodecaedron (Pl. IV, fig. 40.), produced by raising a low, three-sided pyramid on each face of the primitive.—Another form (Pl. IV, fig. 41.), is the tetraedron, truncated on its edges, while each solid angle is terminated by four faces.—The crystals are usually small, and often grouped.—When not tarnished, their external lustre is strong.

(*Chemical characters.*) Before the blowpipe it melts into a grayish, metallic globule, brittle, and not easily reduced. It usually decrepitates, and yields a whitish smoke.—The true composition of Gray copper is still enveloped in some uncertainty, although many researches have been made by Klaproth and others. Chemical facts, however, seem to support the opinion of Count Bournon, that this ore is essentially composed of copper, iron, and sulphur. Several specimens, both amorphous and crystallized, yielded Chenevix these three ingredients only. In a tetrahedral crystal from Cornwall he found copper 52, iron

31, sulphur 14. (*MURRAY*.) This ore, however, usually contains other metals in variable proportions, more particularly *arsenic* and *antimony*. But it appears from the analyses of Klaproth, that some specimens contain a considerable proportion of arsenic with little or no antimony, while others contain much antimony with little or no arsenic. We hence adopt the distinction of Brongniart, and arrange most of its varieties under two subspecies, depending on the presence of *arsenic* or *antimony* in considerable quantities.

Another reason for believing, that all the metals found in this ore, excepting copper and iron, are not essential to the species, is, that their presence or absence does not materially affect the crystalline form or other external characters. This species is consequently composed of the same ingredients as pyritous copper, but in different proportions.

In the Gray Copper of Guadalcanal, in Spain, Vauquelin found variable quantities of platina, sometimes amounting to 10 per cent.—It has been called *Platiniferous Gray Copper*.

(*Distinctive characters.*) Its total want of action on the magnetic needle sufficiently distinguishes it from the magnetic and the specular oxides of iron.—It is less hard than arsenical iron, has usually a darker color, and does not, like that ore, yield the odor of arsenic, when struck.

SUBSPECIES 1. ARSENICAL GRAY COPPER.

Cuivre gris arsenifere. *Haüy*. Cuivre gris arsénié. *Brongniart*. Gray Copper. *Jameson*. Kupferfahlerz. *Hausmann*.

Its color is steel gray, usually rather light. In fact, its external characters are those of the species already given.

A minute fragment, exposed to the flame of a lamp, diffuses a vapor, but does not suffer complete fusion. (*HAUR*.) Three specimens from near Freyberg yielded Klaproth copper 41.0 to 48.0, iron 22.5 to 27.5, sulphur 10.0, arsenic 14.0 to 24.1, silver 0.4 to 0.9, with a trifling loss in each experiment; one specimen contained 1.5 of antimony.

SUBSPECIES 2. ANTIMONIAL GRAY COPPER.

Cuivre gris antimonifere. *Haüy*. Cuivre gris antimonié. *Brongniart*. Schwarzerz. *Werner*. La Mine noire—et grise-riche. *Brochant*. Black Copper. *Jameson*. Schwarzgiltigerz. *Hausmann*.

Its color is steel gray, but usually darker than that of the preceding subspecies, and sometimes passes into iron black. It is also a little harder than the preceding; and its fracture, which is imperfectly conchoidal with small cavities, or uneven, has usually considerable lustre. According to Bournon, a reddish brown streak indicates the presence of both antimony and silver.

When a minute fragment is presented to the flame of a lamp, a vapor appears, and the fragment at length melts into a metallic globule. (*HAUR*) Several specimens from different parts of Germany and

Hungary yielded Klaproth copper 25.5 to 40.25, iron 3.25 to 13.50, sulphur 11.5 to 28.0, antimony 19.5, to 34.09, silver 0 to 14.77; there was a small loss in each experiment, and some of the specimens contained a little zinc, or mercury, or arsenic.

Gray Copper is sometimes *argentiferous*, and is even worked as an ore of silver.

(*Geological situation of the Species.*) Gray Copper exists extensively, and in considerable abundance. It occurs in primitive rocks, where it appears in veins traversing gneiss, mica slate, argillaceous slate, &c. These veins are often very large, and contain various ores and other minerals. Pyritous copper, sulphuret of copper, black copper, sparry iron, red silver, &c. are among its accompanying ores. Its gangues are quartz, the carbonate and fluat of lime, and sulphate of barytes.—It sometimes occurs in beds.

It is found also in transition and even secondary rocks.

(*Localities.*) These are numerous, among which are the mines of Saxony, Hungary, Sweden, Cornwall, &c. At Guadalcanal, in Spain, it contains a few parts of platina, sometimes amounting to 10 per cent. (*VAUQUELIN.*)

In the *United States*. In *Maryland*, Gray Copper has been observed at Pipe Creek, 18 miles from Baltimore. (*HARDEN.*)—Also at Liberty, in Frederick County, with sulphate of barytes. (*SERBERT.*)—In *New York*, near Lake Champlain, in primitive rocks. (*GIBBS.*)—In *Connecticut*, near Hartford, &c. in the red sandstone formation. (*MACLURE.*)

SUBSPECIES 3. TENNANTITE. *PHILLIPS.*

Tennantite. *Jameson.*

Its true color is blackish or lead gray. The surface, however, varies from a shining tin white to a dull iron black. Its powder is reddish gray. It is usually crystallized in dodecaedrons with rhombic faces, either perfect, or variously truncated on the edges;—or in octaedrons and cubes, whose edges and angles are sometimes truncated.—Its structure is imperfectly foliated, and its natural joints appear to be parallel to the planes of the dodecaedron. Its fracture is uneven, with a metallic lustre more or less shining.—It scratches sulphuret of copper and the more common varieties of Gray Copper. Its specific gravity is 4.37.

Before the blowpipe, on charcoal, it burns with a bluish flame, and copiously exhales arsenical vapors, leaving a grayish black magnetic scoria. It contains, according to R. Phillips, copper 45.32, iron 9.26, sulphur 28.74, arsenic 11.84, silex 5.00.

It is found in Cornwall, in veins, which traverse granite and argillite, and is associated with pyritous copper, sulphuret of copper, &c.

Its name alludes to that of the late Mr. *Tennant*, a distinguished chemist.

APPENDIX TO GRAY COPPER.

WHITE COPPER. *JAMESON*.

Weisskupfererz. *Werner*. *Hausmann*. White copper. *Kirwan*. *Aikin*. *Phillips*.

Its color on a recent fracture is nearly silver white, sometimes with a feeble tinge of bluish gray or yellow, but it soon tarnishes with shades of gray, yellowish gray, or brown. It occurs in compact, amorphous masses, whose fracture is uneven or somewhat conchoidal, with a glistening metallic lustre. It yields easily to the knife.—Its specific gravity is sometimes 4.5; and sometimes much higher.

Before the blowpipe it melts into a dark colored slag, and exhales white fumes with the odor of arsenic. It is said to contain 40 per cent. of copper, the remainder being iron, sulphur, and arsenic.

(*Localities.*) This ore is rare. It occurs in Cornwall, Saxony, &c. in primitive rocks; and is accompanied with pyritous copper, sulphuret of copper, &c.

In the *United States*. In *Connecticut*, at *Fairfield*, is found an ore of copper in compact masses, whose recent fracture is a metallic white, which soon tarnishes to a dirty white, inclining to brown, and in time acquires a green coat. Its specific gravity is remarkable, being between 8 and 9. It melts by the blowpipe with abundant fumes of arsenic, and yields with nitric acid a green solution. (*SILLIMAN.*)

SPECIES 5. SELENIURET OF COPPER. *BERZELIUS*.

Its external aspect strongly resembles that of native silver. It is soft, and capable of being hammered and polished.

This mineral is found in a copper mine at *Skrikerum*, in *Smoland*, associated with carbonate of lime, in the fissures of which it sometimes forms dendrites; sometimes also it is disseminated in serpentine. (*BERZELIUS.*)

SPECIES 6. RED OXIDE OF COPPER. *PHILLIPS*.

Cuivre oxidulé. *Hauy*. *Brongniart*. Octahedral Red Copper ore. *Jameson*. Kupferroth. *Hausmann*. Red Copper ore. *Aikin*.

Its ordinary color is a deep cochineal red, which, more particularly in amorphous masses, has often a tinge of lead gray. Its crystals have often a more lively red, which is sometimes a pure carmine, or, by transmitted light, a crimson red. Its streak and powder are nearly brick red. In some impure varieties the red is contaminated by shades of brown or yellow.—It is very easily broken, or scraped with a knife, and does not scratch fluat of lime.

This Oxide is sometimes crystallized in regular octaedrons, or double four-sided pyramids, any two contiguous sides of which, on the same pyramid, are inclined at about $109^{\circ} 28'$. This octaedron, which is the primitive form, is sometimes cuneiform, and sometimes truncated on its angles, or edges, or on both. Sometimes also its edges are bevelled, or each solid angle is replaced by four triangular planes.—It also occurs in cubes, whose edges or angles may be truncated;—and in dodecaedrons with rhombic faces.—The preceding and some other modifications of the primitive octaedron are so variously combined as to produce, according to Phillips, about 100 varieties of secondary forms.—The crystals are usually small, with smooth, highly shining surfaces, often grouped, and sometimes capillary. In some cases, the surface of the crystals is irised, or lead gray, or nearly black and dull.

This ore occurs also in *compact* masses, and is sometimes friable or earthy. Sometimes also it is in lamellæ or thin coats. Its specific gravity is between 4.0 and 6.0.

(*Chemical characters.*) It is not very easily fusible by itself, but, on charcoal, the purer varieties are easily reduced to a metallic state by the blowpipe, without odor. It dissolves in muriatic acid without effervescence; but in nitric acid effervescence takes place, and a green solution is obtained. A specimen from Cornwall, analyzed by Chenevix, yielded copper 88.5, oxygen 11.5. In another from Siberia, Klaproth found copper 91, oxygen 9.

(*Distinctive characters.*) This mineral is well distinguished from other ores of a similar color by its effervescence, while dissolving in nitric acid, and by the green color, which this solution assumes. Further, red sulphuret of mercury is volatile before the blowpipe, and does not dissolve in nitric acid, while red silver dissolves in this acid without effervescence. (*Vauquelin.*)

This Oxide presents a number of varieties.

*Var. 1. FOLIATED RED OXIDE OF COPPER.** This variety occurs both massive and in regular crystals, and sometimes in lamellæ or scales. When in crystals, its color is often a pure and lively red. Its structure is foliated or undulated; its fracture is conchoidal or uneven, and more or less shining, with a lustre slightly metallic or adamantine.—When massive, it has sometimes a granular structure, and is nearly or quite opaque; but the crystals are usually more or less transparent, sometimes only translucent.

2. CAPILLARY RED OXIDE OF COPPER.† PHILLIPS. Its color is, in general, nearly carmine red, sometimes very pure and lively. It occurs

* Blattriches Rothkupfererz, *Werner*. Foliated Red Copper ore, *Jameson*. Le Cuivre oxidé rouge lamelleux, *Brochant*. Blattriches Kupferroth, *Hausmann*.

† Haarformiges Rothkupfererz, *Werner*. Capillary Red Copper ore, *Jameson*. Aikin. Fibrous Red Copper ore, *Kirwan*. Haarformiges Kupferroth, *Hausmann*.

in translucent or transparent capillary crystals, with a shining, silken lustre. The crystals are often aggregated, sometimes into little flakes.

3. COMPACT RED OXIDE OF COPPER.* Its color is cochineal red, often dark, or with a slight tinge of bluish gray. It occurs in opaque, compact masses, whose fracture is even or a little conchoidal with a feeble lustre. Sometimes it merely invests other minerals.

(*Geological situation and Localities.*) The Red Oxide of Copper, though never in very large masses, is by no means an uncommon ore. Most frequently, however, it occurs in metallic veins, which traverse primitive rocks, and almost always accompanies native copper, which it very frequently invests. It is very often associated with malachite and brown iron ochre, and sometimes with pyritous copper, &c. It has also been observed in transition and even secondary rocks.—Though a rich ore, it does not occur in sufficient quantity to be explored by itself.

In Cornwall, fine octaedral crystals of this Oxide are attached to amorphous masses of the same substance; they are sometimes half an inch in one dimension, and sometimes mere points. It is there sometimes accompanied by the green oxide of uranium. (*PHILLIPS.*)—Siberia also furnishes this Oxide in fine groups of octaedral crystals. In the mine of Nikolaew are found insulated octaedrons, which are coated with malachite, and proceed from the interior of a red jasper, in a state of decomposition. (*BRONGNIART.*)—Some of the finest specimens of the capillary variety are found near Cologne. Good specimens are found also at Rheinbreitenbach in Nassau.—It occurs also in Cornwall, &c.—An earthy variety occurs also at Rheinbreitenbach, in dull and nearly cochineal red crusts, investing other ores, principally of copper.

In the *United States*. In *Virginia*, on the property of the late Lord Fairfax, it occurs crystallized. (*HARDEN.*)—In *Pennsylvania*, near Lancaster, with malachite.—Also at the Perkiomen lead mine, where it presents small octaedral, and translucent capillary crystals. (*WETHERILL.*)—In *New Jersey*, with carbonate of copper, &c. in the red sandstone formation. Several mines have here been opened, but have in general been abandoned. (*GIBBS.*)—In *Connecticut*, with native copper, &c. in the greenstone mountains, extending northerly from New Haven. (*SILLIMAN.*)

A variety of this Oxide is sometimes found accompanying crystals of arseniate of copper. If a fragment be exposed to the blowpipe, it simply melts with effervescence, exhaling neither odor nor smoke; but, when supported on charcoal, it exhales the odor of arsenic, which probably proceeds from the decomposition of arsenic acid.

* Dichtes Rothkupfererz. *Werner*. Compact Red Copper ore. *Jameson*. Amorphous Red Copper. *Aikin*.

SUBSPECIES 1. FERRUGINOUS RED OXIDE OF COPPER. PHILLIPS.

Cuivre oxidulé ferrifere. Brongniart. Cuivre oxidulé terreux. Haüy. Ziegelerz. Werner. Tile-ore. Jameson. Brick red copper ore. Kirwan. Kupferbraun. Hausmann. Ferruginous Red Copper. Aikin.

Its color is hyacinth or brick red, usually dull, or mingled with shades of brown, yellow, or gray, thus passing to brownish red, dark gray, &c. It is sometimes friable with an earthy fracture; and sometimes indurated and considerably hard, with an even or somewhat conchoidal fracture. It has little or no lustre; and is opaque.

Before the blowpipe it becomes black, but is infusible by itself. It renders borax a dirty green. It is a mixture of the Red Oxide of Copper and brown oxide of iron, in variable proportions.

This ore is found in those mines, which embrace the Red Oxide of Copper; and of course has the same accompanying minerals.—It is sometimes sufficiently abundant to be explored, and yields from 10 to 50 per cent. of copper.

SPECIES 7. CARBONATE OF COPPER.

This species, as its name indicates, is essentially composed of oxide of copper and carbonic acid. It always presents some shade of *blue* or *green*; and on this difference of color, two subspecies, agreeing in composition and crystalline form, may conveniently be established.

SUBSPECIES 1. BLUE CARBONATE OF COPPER.

Cuivre carbonaté bleu. Haüy. Cuivre azuré. Brongniart. Kupferlazur. Werner. Hausmann. L'Azur de Cuivre. Brochant. Blue Copper. Jameson. Aikin. Phillips. Striated Mountain Blue. Kirwan.

The characteristic color of this subspecies is azure blue, often extremely beautiful and shining; but sometimes it inclines more or less to Prussian or blackish blue, and sometimes it is pale or smalt blue. This mineral preserves its color in oil, and leaves a blue trace, when rubbed on paper. The color of its streak is a light blue.

Even when not friable, it is easily broken, and readily yields to a knife. It is seldom perfectly opaque, and its crystals, usually translucent, are sometimes nearly transparent. Its specific gravity varies from 3.23 to 3.70.

It very frequently occurs in small, shining crystals, of which the primitive form is supposed to be a double four-sided pyramid, whose common base is a rhomb or oblique-angled parallelogram. It presents a considerable number of secondary forms. Among these is a four-sided rhombic prism, truncated on all the lateral edges, and terminated by summits with two or four faces.—Sometimes the alternate solid angles of the prism are truncated.—Sometimes also the four-sided prism is truncated on two opposite lateral edges (Pl. V, fig. 1.), and terminated at each extremity by four faces.—Some of its forms are tabular.—The crystals are usually aggregated into groups or clusters.

This Carbonate of Copper is sometimes in grains, or amorphous masses, or in little plates, or crusts; and often in reniform, stalactical, or botryoidal concretions, striated from the centre to the circumference, and usually presenting a rough or drusy surface.

Its fracture, sometimes imperfectly foliated, usually presents broad, diverging fibres, with a vitreous lustre, more or less shining. Its cross fracture is somewhat conchoidal.

The *Velvet Blue Copper* of Jameson, (*Kupfersammterz* of Werner.) has the color of this Carbonate, being intermediate between smalt and sky blue; but, like the green Carbonate of Copper, it occurs in delicate capillary crystals, which usually form a glistening crust, resembling velvet.

(*Chemical characters.*) This ore dissolves with effervescence in nitric acid. Before the blowpipe it becomes black, but is scarcely fusible by itself; with borax, to which it communicates a fine green, it yields a globule of copper. It contains, according to Vauquelin, oxide of copper 68.5, carbonic acid 25.0, water 6.5. Another analysis by Klaproth gives oxide of copper 70, carbonic acid 24, water 6. When heated to 212° Fahr., it gives up its water, becomes brown, and in this state may probably be employed as a pigment. (*COLIN & TAILLEFORT.*)

It is very remarkable that oxide of copper, combined with ammonia, has the same color and crystalline forms, which this species exhibits.

This Carbonate resembles the azure phosphate of iron; but the latter becomes darker or brownish in oil, and by the blowpipe is converted into a scoria, obedient to the magnet.

*Var. 1. EARTHY BLUE CARBONATE OF COPPER.** Its color is pale, or nearly smalt blue. It occurs in thin coats, or small friable masses, composed of dull, earthy particles. It appears to be rendered impure by earthy substances.

(*Geological situation and Localities.*) This species occurs only in small quantities, either disseminated in ores and other minerals, or investing their surfaces. It exists in both primitive and secondary rocks, accompanying other ores of copper, more particularly the green carbonate of copper, pyritous copper, and gray copper; and is very often connected with the brown oxide of iron. It is also associated with the carbonate and phosphate of lead, sulphuret of iron, lead, &c. Its crystals are sometimes found ornamenting the cavities of its accompanying minerals.

In Chili, it occurs in veins, which traverse granite, and contain also cinnabar, carbonate of lead, &c.—In Bohemia, it appears in gneiss.—In the Harz, in graywacke.—In Thuringia, in sandstone.—Fine specimens

* *Cuivre carbonaté bleu terreux. Haüy. Erdige Kupferlazur. Werner. Earthy Blue Copper. Jameson. Aikin. Earthy mountain blue. Kirwan. Zerreibliche Kupferlasur. Hausmann.*

are found in Siberia, Moldavia, the Bannat, and at Chessy in France.—The variety in acicular crystals, called Velvet Blue Copper, has been found at Oravicza, in the Bannat, but is very rare.

In the *United States*. In *Pennsylvania*, at the Perkiomen lead mine; it occurs in minute, dark blue crystals in veins, which contain galena and blende, and traverse the red sandstone formation. (*CONRAD. LEA.*) The earthy variety occurs at the same place. (*WETHERILL.*)—In *New Jersey*, at Schuyler's mines.

(*Remarks.*) This mineral is sometimes employed as a paint, of which there is said to be a manufactory in the Tyrol.—Quartz or calcareous substances, penetrated by this salt of copper, have been called *Armenian stone*.

SUBSPECIES 2. GREEN CARBONATE OF COPPER.

Cuivre carbonaté verte. *Haüy.* Cuivre malachite. *Brongniart.*

This interesting salt of copper has always a green color; most frequently it is emerald, grass, or apple green, but varies to leek or verdigris green; and in some impure varieties it becomes olive or pistachio green. Its streak and powder are also green, but paler. Its hardness is moderate; it may easily be scratched by a knife, and is sometimes friable. Its specific gravity lies between 3.57 and 3.99.

It is sometimes in fibres, or fibrous masses, which are often delicate and silky; sometimes in concretions, whose texture is more or less compact; and sometimes it is amorphous.

This subspecies rarely occurs in distinct crystals, whose forms can be determined. It has been observed in minute four and six-sided prisms, bevelled at the extremities.—Also in rhombic prisms with diedral summits, partly green and partly blue.—Some of the crystals, which it presents, may have once belonged to other ores of copper, having undergone a change of composition, but still retaining their original form. Thus it appears in octaedrons or dodecaedrons with rhombic faces, and may be derived from the red oxide of copper, a nucleus of which is said to be sometimes found in the crystal.

(*Chemical characters.*) This mineral dissolves with more or less of effervescence in nitric acid, and gives a green solution. To ammonia it *slowly* communicates a blue color. Before the blowpipe it blackens, frequently decrepitates, and, by continuing the heat, may be reduced to a metallic state. It melts, and is easily reduced with borax. To the flame of burning bodies it gives a green tinge. It contains, according to Klaproth, oxide of copper 70.5, carbonic acid 18.0, water 11.5. The analysis of Vauquelin gives oxide of copper 70.1, carbonic acid 21.2, water 8.7. When deprived of its water of crystallization by a moderate heat, it becomes brown, and may be employed as a pigment.

(*Distinctive characters.*) Its effervescence in nitric acid may serve to distinguish it from the green oxide of uranium, the green phosphate of lead, and the green arseniate of copper.—It often much resembles the muriate of copper; but this latter salt dissolves in nitric acid without effervescence, and *immediately* produces a blue color in ammonia.

This species presents a number of varieties, most of which pass into each other.

Var. 1. FIBROUS MALACHITE. KIRWAN. JAMESON.* The structure of this very beautiful variety is distinctly fibrous; and the fibres, which are usually delicate and capillary, are collected into small masses, or more frequently into little bundles or tufts, in which they diverge more or less, and are sometimes stellular. Its predominant color is a lively emerald green, glistening with the lustre of silk; but sometimes passes to grass or leek green. When the fibres are short, these tufts have the soft and shining aspect of green velvet.

These fibres are, in fact, translucent crystals, whose forms are indeterminable; and the masses, produced by their aggregation, when broken, commonly exhibit a fibrous structure with a glistening lustre more or less silky.

This variety most frequently appears on the surface of other ores, more particularly the sulphuret of copper, gray copper, red oxide of copper, pyritous copper, brown and argillaceous oxides of iron, and is often associated with the azure carbonate of copper.

(*Localities.*) Though in small quantities, it is not an uncommon ore. Some of the finest specimens come from the Uralian mountains in Siberia.

In the *United States*. This variety has been observed in *Pennsylvania*, at the Perkiomen lead mine.—In *New Jersey*, at Schuyler's mines, in emerald green groups of crystalline fibres, diverging from a point, or in tufts of short fibres, resembling velvet; it is sometimes associated with sulphuret of copper and carbonate of lime. (*PIERCE & TORREY.*)—In *Connecticut*, at Cheshire, &c. in small but good specimens.

2. COMPACT MALACHITE.† KIRWAN. JAMESON. Its color is frequently emerald green, but passes to verdigris, apple, or grass green; indeed the shade of green often varies in the same specimen. It has little or no external lustre; and is opaque, or translucent at the edges.

This variety is sometimes amorphous, in plates, tuberous, or stalactical, but more frequently in globular, reniform, or botryoidal concretions. These concretions are composed of parallel, curved, or undulated layers,

* Fasriger Malachit. *Werner. Hausmann.* Cuivre carbonaté vert aciculaire. *Hauy.* Cuivre Malachite soyeux. *Brongniart.* La Malachite fibreuse, *Brochant.* Malachite. *Aikin.* Fibrous Malachite. *Phillips.*

† Dichter Malachit. *Werner. Hausmann.* Cuivre carbonaté vert concrétionné. *Hauy.* Cuivre Malachite concrétionné. *Brongniart.* La Malachite compacte. *Brochant.* Massive Malachite. *Aikin.* *Phillips.*

often striated in the direction of their thickness, and differ so much in their shades of green, that the mass has a striped aspect. They often contain numerous cavities in their interior.—The surface of the concretions, and of the layers, which compose them, is often greenish white, or invested with a thin crust of earthy malachite, or exhibits black dendrites.

Its fracture sometimes presents extremely minute, diverging fibres, and sometimes appears even or a little conchoidal, or passes into uneven. Though sometimes nearly dull, it often has a moderate and silken lustre.

Compact Malachite is found in the cavities of metallic veins. It is often associated with the fibrous variety, and other ores of copper.—Some of the best specimens come from the Uralian mountains, Hungary, and the Tyrol.

In the *United States*. In *Maryland*, it occurs on the Blue Ridge.—In *Pennsylvania*, 2 miles N. from Nicholson's Gap. (*HARDEN*.)—Also at the Perkiomen lead mine.—In *New Jersey*, near Boundbrook, in trap rocks. (*GIBBS*.)—Also at Schuyler's mines in mammillary concretions, and sometimes accompanied by red oxide of copper. (*PIERCE & TORRER*.)—In *Massachusetts*, at Greenfield, 100 rods below the Falls, with pyritous copper, in a vein traversing toadstone, and containing sulphate of barytes. (*HITCHCOCK*.)

(*Uses and Remarks*.) Compact Malachite is often in masses considerably large, and, when sufficiently compact, is sometimes sawed into tables. These tables, when highly polished, are rendered very beautiful by their different shades of green, arranged in parallel zones, and by their soft and silken lustre. A rare table of Malachite, about 33 inches by 18, exists at St. Petersburg.—This variety is sometimes employed as a pigment.—The name, *Malachite*, is derived from the Greek, *μαλαχη*, *mallow*, in allusion to its color.

(*Geological situation of the Species*.) The Green Carbonate of Copper, of which the fibrous and compact Malachite are the most common varieties, occurs in all classes of rocks from the oldest to the newest, and accompanies most of the other ores of copper. It is often connected with the brown oxide of iron, and sometimes with the ores of other metals.

The blue and Green Carbonates of Copper are sometimes intimately mixed in the same specimen.

APPENDIX TO CARBONATE OF COPPER.

COPPER GREEN.

Kupfergrun. *Werner*. Common Copper Green. *Jameson*. Cuivre carbonaté vert terreux et résinoïde-compact. *Haüy*. Cuivre Malachite Chrysocolle et ferrugineux. *Brongniart*. Mountain Green. *Kirwan*. Le vert de Cuivre. *Brochant*. Kiesel Malachit, Erdiger Malachit, and Eisenschussiges Kupfergrun. *Hausmann*. Chrysocolla. *Aikin*. *Phillips*.

This appendix embraces certain impure ores of copper, which are usually known by the name of Copper Green. They exhibit considera-

ble diversity both in their external characters, and composition; and some of them do not appear to be even a carbonate of copper. But the several varieties have not yet been sufficiently analyzed to determine their true composition, and to connect this with their external characters. (See chemical characters.) It exhibits several shades of green, passing from verdigris and leek green to olive green, yellowish or whitish green, bluish, blackish, or brownish green, and several shades of brown. It is sometimes translucent in thin pieces, or at the edges, and sometimes opaque. It occurs amorphous, in crusts, and sometimes reniform, botryoidal, or stalactical. Its fracture is conchoidal with small cavities, and a resinous lustre, more or less shining, or sometimes it is dull and earthy. It is easily broken, and generally yields with ease to the knife; but it varies much in hardness, being sometimes friable, and sometimes yielding with difficulty to a knife. Its specific gravity varies from 2.0 to 2.4.

(*Chemical characters.*) It is infusible by the blowpipe, but becomes blackish or brown. With borax it easily melts, tinges the flame green, and yields metallic copper. Most varieties effervesce very slightly in muriatic or nitric acid. The oxide of copper is however dissolved by the acid, leaving a siliceous residue. A specimen from Mexico yielded Thomson oxide of copper 54.5, carbonic acid 15.0, silex 25.3; = 94.8. In another from Siberia, Klaproth found oxide of copper 50, carbonic acid 7, water 17, silex 26. A specimen, analyzed by John, yielded oxide of copper 49.6, carbonic acid 3.0, water 17.5, silex 28.4, sulphate of lime 1.5. The olive green and brownish varieties, according to Vauquelin, are composed of oxide of copper, water, and silex.—An opaque specimen, of an asparagus or a celandine green color, occurring in crusts, with an earthy or even fracture, nearly or quite dull, yielded John oxide of copper 45.8, water 21.8, silex 29.0, sulphate of lime 3.0. He calls it *Kieselkupfer* (siliceous copper).—In fine, some specimens contain oxide of iron, and become magnetic, when roasted.

It appears from the preceding analyses, that some varieties contain variable quantities of carbonic acid, and exist perhaps in the state of a siliceous carbonate or subcarbonate of copper; while others are destitute of this acid, and form a siliceous hydrate or oxide of copper; and others may be a mixture of the preceding. Some of its varieties ought probably to be associated with the Diopside.

Its feeble effervescence in acids will serve to distinguish it from compact malachite, which it sometimes resembles.—The same specimen sometimes exhibits different external characters, being partly green and translucent, and partly brownish and opaque, and sometimes passing by insensible shades to a substance resembling decomposed feldspar, or ferruginous hornstone.

It accompanies other ores of copper, particularly the red oxide, pyritous copper, and malachite. It occurs in Bohemia, Thuringia, the Harz, Hungary, &c. In Cornwall, it is associated with arseniate of copper.

SPECIES 8. ANHYDROUS CARBONATE OF COPPER.

Brown Copper. Jameson.

The color of this new ore of copper, in pure specimens, is dark blackish brown; but it generally appears variegated with green and red from an intermixture of malachite and red oxide of iron. It is easily scratched by a knife; and yields a reddish brown powder. Its fracture is conchoidal with small cavities, and nearly dull. Its specific gravity is 2.62.

It dissolves with effervescence in acids, and deposits a red powder. It contains, according to Thomson, peroxide of copper 60.75, carbonic acid 16.70, peroxide of iron 19.5, silex 2.1; = 99.05.

It is found in Hindostan, near the eastern border of the Mysore country, and is associated with malachite.

It was first described by Dr. Thomson.

SPECIES 9. DIOPTASE. BROCHANT.

Cuivre Dioptase. Haüy. Brongniart. Kupferschmaragd. Werner. Dioptas. Hausmann. Emerald Copper. Aikin. Dioptase. Jameson. Phillips.

This rare mineral has usually a fine emerald green color, and is, in general, more or less translucent. It scarcely scratches glass; and its specific gravity is about 3.30.

It has been observed only in six-sided prisms, terminated by three-sided pyramids, whose faces stand on alternate, but different lateral edges at the two extremities. Its natural joints are obvious; and hence its name from the Greek *δια* and *οπτομαι*, to see. Its primitive form is an obtuse rhomb. Its structure is foliated, the laminæ separating in three different directions. Its fracture is conchoidal; and its lustre is shining and nearly vitreous.

Before the blowpipe it decrepitates, becomes brown or bluish, tinges the flame yellowish green, and, by urging the heat, eventually melts. With borax it yields a globule of copper. A specimen, analyzed by Lowitz, yielded oxide of copper 55, silex 33, water 12.—It appears to be a siliceous oxide or hydrate of copper.

Its inferior hardness, greater specific gravity, and the negative electricity, which it acquires by friction, when insulated, distinguish it from the emerald.

It is brought from Siberia, associated with malachite, and carbonate of lime.

SPECIES 10. MURIATE OF COPPER.

Cuivre muriaté. *Hauy. Brongniart. Brochant.* Salzkupfererz. *Werner.* Atacamite, *Jameson.* Smaragdochalzit. *Hausmann.* Muriate of Copper. *Aikin. Phillips.*

The color of this mineral varies from emerald to leek or verdigris green, or even blackish green, and is sometimes grass or olive green. Its streak is a paler green.

It is sometimes in minute, shining octaedrons, often elongated or cuneiform. The solid angles about the common base are sometimes replaced by two or four faces; and the two edges, which form the summits of these elongated octaedrons, are sometimes truncated. Hence these crystals often resemble four or six-sided prisms with bevelled extremities and other modifications. Their primitive form is an octaedron, of which two opposite edges at the common base contain each an angle of $107^{\circ} 10'$, and the other two an angle of $112^{\circ} 43'$.

Sometimes it appears in lamellæ, or in lamellar masses.—It occurs also in acicular fibres, much resembling those of malachite; sometimes also in masses or concretions with a radiated structure, or nearly compact; and sometimes in minute grains.

The structure of the crystallized varieties is more or less distinctly foliated. It is easily broken; and its fracture is somewhat shining. Its crystals are more or less transparent; but the other varieties are translucent at the edges or opaque. Its specific gravity is between 3.52 and 3.75.

(*Chemical characters.*) When projected on ignited charcoal before the blowpipe, it communicates to the flame a peculiar and very beautiful color, both green and blue; the vapor of muriatic acid is exhaled, and a globule of copper remains. Its powder, thrown into ammonia, almost instantly communicates a lively blue color. In nitric acid it dissolves without effervescence, forming a green solution. A specimen from Chili yielded Proust oxide of copper 76.6, muriatic acid 10.6, water 12.8. The sandy variety from Peru afforded Klaproth oxide of copper 73, muriatic acid 10.1, water 16.9.

(*Distinctive characters.*) Its solubility in nitric acid without effervescence, the color it gives to flame, and the rapidity, with which it renders ammonia blue, will distinguish it from the green carbonate of copper.—From arseniate of copper it differs by not exhaling an arsenical odor before the blowpipe.

*Var. 1. SANDY MURIATE OF COPPER.** This variety was first known. It occurs in minute grains, like sand. This green sand, however, appears to be composed, in part at least, of crystals, either entire or in fragments, and is usually mixed with a little quartz.

* Cuivre muriaté pulverulent. *Hauy. Brongniart.* Kupfersand. *Werner.* Green sand of Peru. *Kirwan.* Arenaceous Atacamite. *Jameson.*

(*Localities.*) Muriate of Copper has been found chiefly in Chili and Peru.—At Remolinos in Chili, it is mixed with brown oxide of iron, and accompanied by malachite, quartz, &c.—In Peru, it is associated with ores of silver.—It occurs also at Virneberg on the Rhine;—and at Schwarzenberg, in Saxony.—At Vesuvius, in the fissures of lava with muriate of soda.

The sandy variety is found in the sand of the river Lipes, in the desert of Atakama, between Chili and Peru.

In the *United States.* In *Massachusetts*, at Woburn, in plates and small tuberous masses, investing pyritous copper; at Brighton it invests quartz and amygdaloid; and at Medford it is in rolled masses of granite. (*J. F. & S. L. DANA.*)

This species is probably more common, than has generally been supposed, having been frequently confounded with malachite.

SPECIES 11. SULPHATE OF COPPER. PHILLIPS.

Cuivre sulfaté. *Hauy. Brongniart.* Kupfervitriol. *Werner.* Prismatic vitriol. *Jameson.*

Blue Vitriol.

This very beautiful salt of copper is but seldom found native. It has a deep and rich sky blue color, a styptic and disagreeable taste, and is very soluble in water. When rubbed on polished iron a little moistened, it leaves a reddish trace of copper.

Its artificial crystals are prismatic, having four, six, eight, or ten sides. *Hauy* mentions eleven varieties of form, of which the primitive and one secondary form are represented in Pl. V, fig. 2 and 3.

By the analysis of *Proust*, Sulphate of Copper contains oxide of copper 32, sulphuric acid 33, water 36.

Its solubility and taste distinguish it from the blue carbonate of copper.

It is found in the waters of those mines, which contain the sulphuret of copper, from the decomposition of which it undoubtedly proceeds. From solution in these waters it is deposited on other minerals in the form of a powder or crust, or in concretions, or sometimes in crystals.

(*Uses and Remarks.*) Its principal use is in dying. It is also employed to communicate a brown color to fowling pieces, &c.

The Sulphate of Copper, employed in commerce, is obtained either from the natural waters just mentioned, or by roasting poor ores of pyritous copper, exposing the residue to air and moisture, and by subsequent lixiviation and crystallization.

SPECIES 12. PHOSPHATE OF COPPER. JAMESON.

Cuivre phosphaté. *Hauy. Brochant. Brongniart.* Phosphor Kupfer. *Werner.* Pseudomalachit. *Hausmann.* Phosphate of Copper. *Aikin. Phillips.*

The color of this mineral, observed on a recent fracture, is emerald green, or between emerald and verdigris green, sometimes a little

spotted with black, and sometimes shaded with brown or yellow. Its external surface is dark green, or even greenish black. Its powder and streak are pale green. It scratches carbonate of lime, but is less hard than glass. It is sometimes nearly or quite opaque, unless in very thin fragments; but its crystals are sometimes almost transparent.

It is sometimes crystallized in octaedrons, of which two opposite faces, taken on one pyramid, form with the corresponding faces of the other pyramid, at the common base, angles of $109^{\circ} 30'$; the other two edges, which form the common base, contain angles of $94^{\circ} 14'$. (*PHILLIPS.*) This octaedron is sometimes elongated, its summits truncated, and its solid angles variously modified by small planes; and hence it often assumes the aspect of an oblique-angled four-sided prism, truncated on two of its edges.—These crystals are often small, and appear in shining groups or druses; sometimes indeed they are so minute, that they resemble a mere mould.—Its structure is foliated in two directions, parallel to the planes of the octaedron. Its lustre, which is usually resinous or silken, is sometimes feeble, and sometimes it is strong and nearly vitreous on the surface of the laminae.

It also occurs in thin plates, and in mammillary, reniform, or botryoidal concretions, composed of delicate, diverging fibres, with a silken lustre. These concretions are sometimes nearly compact, and present a conchoidal or splintery fracture.—Its specific gravity is between 4.0 and 4.3.

(*Chemical characters.*) On charcoal it melts before the blowpipe into a dull, brittle globule of a grayish or blackish color; and by continuing the heat, with the addition of tallow, a globule of a copper red color is obtained. In nitric acid it dissolves without effervescence, forming a pale or bluish green solution. It contains oxide of copper 68.13, phosphoric acid 30.95;=99.08. (*KLAPROTH.*)

Its chemical characters will serve to distinguish it from the green carbonate, arseniate, and muriate of copper.

(*Localities.*) At Firneberg, near Cologne, it occurs in a gangue of opaque, white, cavernous quartz, associated with other ores of copper.—At Schemnitz and Newsohl in Hungary, in quartz.—In Cornwall, in Gunnis Lake mine, it occurs both crystallized and fibrous, in veins with the arseniate and other ores of copper.—In Chili, at Farallon and Faluen.

SPECIES 13. ARSENIATE OF COPPER. BOURNON.

Cuivre arseniaté. Haüy. Brochant. Brongniart. Arseniate of Copper. Aikin. Phillips.

This mineral, although rare and but recently examined, has already presented a great diversity of external characters, and even of composition, in regard to the proportions of its ingredients. It is hence almost impossible to give those general, definite, external characters, which

may enable one to recognise all the varieties with certainty. Chemistry, however, very readily offers its assistance to decide the fact, which other characters may leave doubtful.—It is, indeed, uncertain whether all the substances, which at present are comprised in this species, and which are composed chiefly of oxide of copper and arsenic acid, do in fact belong to the same species. A permanent difference in the degree of oxidation of the copper, or the presence or absence of water may yet show, that this species ought to be divided into two or more distinct species.

Its predominant colors are green and blue of different shades, either pale or deep, and sometimes intermixed; sometimes also the green is more or less contaminated with shades of brown or yellow, or even passes into gray, or pale greenish white.

Its hardness is variable, but never enables it to scratch glass. It usually occurs in crystals or fibres; and these fibres are often collected into small masses, whose structure is radiated, and whose surface has the lustre of silk. The primitive form of the crystals is supposed by Haüy to be an octaedron.

(*Chemical characters.*) In nitric acid it dissolves without effervescence, yielding a greenish solution. To ammonia its powder rapidly communicates a fine blue. Before the blowpipe it sometimes decrepitate, and on charcoal melts, diffusing a very sensible odor of arsenic, while those parts of the globule in contact with the charcoal are reduced to a metallic state. With borax it is more easily fused and reduced.

(*Distinctive characters.*) To distinguish this from some other green ores, it may be remembered, that green carbonate of copper effervesces with nitric acid;—that the green oxide of uranium yields a yellowish solution in the same acid; and that the green muriate of copper does not exhale an arsenical odor before the blowpipe.

The following are the most important varieties hitherto observed.

Var. 1. OBTUSE OCTAEDRAL ARSENIATE OF COPPER.* Its usual color is sky blue, more or less deep, sometimes passing to bluish white, verdigris or grass green, or greenish white, some of which, however, are often only superficial. It occurs in small, shining crystals, whose form is an obtuse octaedron, composed of two four-sided pyramids with rectangular bases. According to Bournon, two opposite faces of the same pyramid unite at the summit under an angle of 130° , and the other two under an angle of 115° . This octaedron, which is sometimes cuneiform, is divisible parallel to its sides, and is hence supposed to be the primitive form.—These crystals are translucent, and their external lustre is vitreous. They are very brittle, and have a specific gravity of 2.88. They scratch the sulphate, but not the fluuate, of lime.

* Cuivre arseniaté octaédre obtus. *Brochant.* Cuivre arseniaté obtus. *Brongniart.* Linsenerz. *Werner.* Lenticular Copper. *Jameson.* Cuivre arseniaté primitif. *Haüy.* Linsenkupfer. *Hausmann.* Octahedral Arseniate of Copper. *Aikin.* *Phillips.*

It contains oxide of copper 49, arsenic acid 14, water 35;=98.
(*CHENEVIX.*)

2. ACUTE OCTAEDRAL ARSENATE OF COPPER.* Its color is brownish or yellowish green, varying from olive green to leek or blackish green. Though sometimes blackish on the surface, its streak has constantly a shade of green. Its crystals, which are small and often aggregated, are acute octaedrons, of which two opposite faces in each pyramid unite at the summit under an angle of 84° , and the other two under an angle of 68° ; or, according to Phillips, the angles are 90° and $69^{\circ} 5'$. These octaedrons are often cuneiform, and so elongated, that they assume the aspect of a four-sided prism with diedral terminations; two opposite lateral edges of this prism are sometimes truncated. They are semi-transparent, or only translucent.—This is the hardest variety, and scratches fluat of lime. Its specific gravity is 4.28.

It also occurs in capillary prisms, which sometimes terminate in extremely minute fibres, having a silken lustre.

Before the blowpipe it boils, and yields a hard reddish brown scoria. It contains oxide of copper 60.0, arsenic acid 39.7;=99.7.
(*CHENEVIX.*)

3. HEXAEDRAL ARSENATE OF COPPER.† *AIKIN. PHILLIPS.* Its color is a fine emerald green, sometimes passing to verdigris green, or greenish white. It occurs chiefly in hexagonal plates or tables, bounded by six narrow trapezoidal faces, three of which, taken alternately, are inclined toward one of the broader faces, and the remaining three toward the other. Three alternate edges of those, which surround the broad hexaedral faces, are sometimes truncated.—Its structure, parallel to the broader faces, is perfectly foliated.

These plates often form small masses, divisible like those of mica; their lustre on the broader faces is splendid, and a little pearly, or metallic. They are translucent or even transparent, according to the thickness.

This variety is soft, slightly scratching the sulphate, but not the carbonate, of lime. Its specific gravity is 2.54.

It is composed of oxide of copper 58, arsenic acid 21, water 21.
(*CHENEVIX.*)

4. PRISMATIC ARSENATE OF COPPER.‡ Its color is verdigris or bluish green of different shades; but, by the action of the air, its surface often becomes blackish green, bluish black, or black. The streak, however,

* *Cuivre arseniaté octaédre aigu. Haüy. Brochant. Cuivre arseniaté aigu. Brongniart. Blattriches Olivenerz. Werner. Foliated acicular Olivenite. Jameson. Gemeines Oliven Kupfer. Hausmann. Prismatic Arseniate of Copper. Aikin. Phillips.*

† *Cuivre arseniaté lamelliforme. Haüy. Brochant. Brongniart. Kupfer Glimmer. Werner. Hausmann. Prismatic Copper Mica. Jameson.*

‡ *Cuivre arseniaté prismatique triangulaire. Haüy. Cuivre arseniaté triedre. Brongniart. Variety of Olivenerz? Werner. Trihedral Arseniate of Copper. Aikin. Phillips.*

discovers the true color. It occurs in small, triangular prisms, whose sides are feebly and transversely striated; one of the lateral edges being sometimes truncated.—It also assumes the form of a tetraedron, and acute rhomb, the summits of the rhomb being often deeply truncated by triangular planes, and the crystals so grouped, that these planes only appear. The small crystals are often transparent, and transmit a blue or greenish blue light.—This variety scarcely scratches carbonate of lime; and its specific gravity is 4.28.

It also occurs in masses, composed of curved, lamellar concretions, and is sometimes mammillary.

Before the blowpipe it flows, like water, and, in cooling, crystallizes in small, brown, rhombic plates. It contains oxide of copper 54, arsenic acid 30, water 16. (*CHENEVIX.*)

Other regular forms of the Arseniate of Copper are mentioned by mineralogists.

5. FIBROUS ARSENATE OF COPPER.* Its colors are grass green, and olive green, more or less mingled with yellow or brown; sometimes also it is brown or yellow, bluish green, pale greenish or satin white.

It sometimes appears in delicate fibres or capillary crystals, either parallel or diverging, and loosely united. These fibres are sometimes flexible; and sometimes they are so short, delicate, and confusedly grouped, that they resemble the fine dust of cotton.—In some cases, the fibres project from the surface of reniform masses of the same substance.

It also occurs in reniform or mammillary masses, whose structure, like that of malachite, presents delicate, diverging fibres, glistening with a silken lustre. The colors are often arranged in parallel or even concentric zones.—It is opaque, or slightly translucent; and its specific gravity is about 4.28.

It contains, according to Chenevix, oxide of copper 50, arsenic acid 29, water 21. The reniform masses are liable to decomposition, during which the fibres separate and become yellowish, or eventually whitish gray.

This variety sometimes resembles the fibrous oxide of tin.

6. EARTHY ARSENATE OF COPPER.† Its colors are usually olive, verdigris, or yellowish green. It occurs in dull, opaque, earthy masses, sometimes forming a crust.

* *Cuivre arseniaté fibreux. Brochant. Cuivre arseniaté aciculaire—et mamelonné fibreux. Haüy. Fasriges Olivenerz. Werner. Fibrous acicular Olivenite. Jameson. Hematitic and Amianthiform Arseniate of Copper. Aikin. Phillips. Fasriges Oliven Kupfer. Hausmann.*

† *Cuivre arseniaté terreux. Haüy. Earthy acicular Olivenite. Jameson. Erdiges Oliven Kupfer. Hausmann.*

SUBSPECIES 1. FERRUGINOUS ARSENATE OF COPPER.

Quivre arseniaté ferrifère. *Haüy. Brochant. Brongniart.* Radiated acicular Olivenite. *Jameson.* Martial Arseniate of Copper. *Aikin. Phillips. Strahlerz. Werner.* Strahlen Kupfer. *Hausmann.*

The color of this mineral is pale blue, or light brownish yellow with sometimes a shade of green. Its surface is sometimes verdigris or blackish green. It occurs in reniform masses, whose surface presents groups of small, shining crystals. Their form is a rhombic four-sided prism, terminated at each extremity by four triangular faces, placed obliquely on the sides of the prism, whose lateral edges are sometimes truncated. Its specific gravity is 3.40.—It is translucent in different degrees, and sometimes nearly transparent.

It contains oxide of copper 22.5, oxide of iron 27.5, arsenic acid 33.5, water 12.0, silex 3.0 ;=98.50. (*CHENEVIX.*)

(*Geological situation and Localities of the Species.*) The several varieties of Arseniate of Copper have been found chiefly in the mines of Huel Muttrell, Huel Gorland, Huel Unity, Tincroft, &c. in Cornwall. They are associated with quartz, several ores of copper, brown oxide of iron, &c. This Arseniate has also been found in Germany.

In the *United States* ; in *Virginia*, Shenandoah County, it incrusts the oxide of manganese. (*HARDEN.*)*

(*Geological remarks on ores of Copper.*) The most important and abundant ores of Copper are found chiefly in primitive rocks, such as gneiss, mica slate, &c. but rarely in the oldest formations of granite. They however occur in transition and even secondary rocks. Native and pyritous copper, gray copper, the red oxide and sulphuret of copper are among the oldest ores of this metal ; while the blue and green carbonates extend from the oldest to the newest rocks.

Ores of Copper, seldom in beds, are usually found in veins, of which they sometimes constitute but a small part, being mingled with earthy, saline, or metallic substances. Veins of Copper *intersect* most of the other metallic veins, which occur in the same rocks ; and of course must be more recent, than the *intersected* veins.

(*Copper mines.*) In France, are the copper mines of Baigorry in the Pyrenees, and of St. Bell and Chessy, near Lyon.—In Great Britain, are numerous and productive veins of copper. The metalliferous mountains of Cornwall are composed mostly of granite and argillite, and the copper ores, which they furnish, are chiefly pyritous and native copper and the red oxide of copper. All the ores of Cornwall are in veins, which are there often called *Lodes*. The metalliferous veins are intersected by other veins, which *heave* or disturb the course of the

* Other ores of copper are sometimes described ; but they appear to be merely mixtures of some of the preceding species with other minerals. Thus *copper slate* is a bituminous marlite, impregnated with pyritous copper, &c.—*Bituminous copper* is nearly allied to the preceding.—*Bell metal ore* is a mixture of ores of copper and tin.

former, and seldom contain any metallic ores. Some of the metalliferous veins have been explored to the depth of 1250 feet.

The Copper mines of Cornwall, during the year ending June 1820, yielded about 6900 tons of good copper, obtained chiefly from pyritous copper. The whole number of mines now worked in Cornwall is more than 100, of which about 70 yield copper, or copper and tin.

The Copper mines of Anglesea are very productive, and consist chiefly of pyritous copper, which yields from 16 to 40 per cent.—Copper mines are worked also in Devonshire, &c.

In Delicarlia, Sweden, is the ancient Copper mine of Fahlun. Although the ore is not rich, these mines have been very productive.—In Germany, at Riegeldorff, a bituminous marlite, impregnated with pyritous copper, &c. and bearing impressions of fish, is explored as an ore of copper.—The Uralian Mountains in Siberia furnish some remarkable mines of copper. Those of Goumechew and Tourinski are situated in primitive mountains, composed of argillaceous slate, porphyry, &c. The ore is composed chiefly of native copper, sulphuret of copper, and malachite; and the vein, which contains it, traverses beds of white granular limestone. Its gangue is clay variously colored.—Copper mines are also explored at Herngrund, &c. in Hungary—in Austria—in Japan, &c. in the East Indies—and in Coquimbo, &c. in South America.

GENUS VIII. *IRON*.

No one, who examines the universal and abundant diffusion of Iron, the most important of the metals, can disregard so strong an indication of the benevolence of the Creator. This metal is united with other minerals in proportions so extremely variable, that it is sometimes difficult to say, whether a given mineral shall, or shall not, be called an *ore* of iron.

Pure Iron has a bluish gray color. It is the hardest of the metals, and is more or less malleable at all temperatures. Its ductility is extremely great, and permits it to be drawn into finer and stronger wire, than that of any other metal. Its texture is fibrous or granular, and its specific gravity is about 7.70. It is always attracted by the magnet, but does not, when perfectly pure, long retain magnetic properties. It is susceptible of a high polish.

Iron is oxidated both by air and moisture; and is soluble in all the acids. At about 158° W. it melts. In oxygen gas it burns with great brilliancy. That, which is commonly called *rust* of iron, is one of its oxides, sometimes combined with a little carbonic acid.

Whenever Iron occurs in its metallic state, it is easily recognised by being obedient to the magnet. When in the state of an oxide, if the oxygen do not exceed about 30 per cent. or, when combined with

sulphur, if the sulphur do not exceed about 40 per cent. it is still more or less affected by the magnet. Carbon and phosphorus also, as well as sulphur, when combined with iron, enable it to retain the magnetic fluid. But the presence of arsenic, manganese, and antimony may counteract the magnetism of iron.—Prussic acid has a strong affinity for iron, and detects it in any of its combinations, yielding a blue prussiate of iron.

A fragment, supposed to be an ore of iron, may be examined by gradually roasting it in a platina spoon, and then exposing it, mixed with some fatty substance, on charcoal to the greatest heat of the blow-pipe; if the globule, thus obtained, embraces iron even in small quantity, it will be magnetic. But, as both cobalt and nickel are also magnetic, this globule may be dissolved in muriatic acid, and, if it contain iron, the prussiate of potash and iron will produce a blue precipitate.

(*Uses.*) We shall say nothing of the numerous and well known uses of Iron in its different states. It may be well to remark, that *crude* or *cast* or *pig* iron usually contains both oxygen and carbon, and sometimes also phosphorus, manganese, silex, &c.—that when deprived of most of these foreign ingredients, it constitutes *forged* or *bar* iron—and that steel is pure iron, combined with from about $\frac{1}{180}$ to $\frac{1}{140}$ of its weight of carbon.

SPECIES 1. NATIVE IRON. KIRWAN.

Gediegen eisen. Werner. Hausmann. Fer natif. Haüy. Brongniart. Brochant. Octahedral Iron. Jameson. Native Iron. Aikin. Phillips.

Native iron differs somewhat in its characters from forged iron. Its color is whiter, being a light steel gray. It is usually more malleable, than forged iron, and not so easily oxidated by exposure to the weather. But, although its surface may be covered with a brownish crust, its streak has a metallic lustre.

Native iron has been observed in masses, thin plates, or leaves, or under a ramous or stalactical form, or even in octahedral crystals. Thus, according to Schreiber, Native iron exists in the mountain of Oulle, near Grenoble, in a vein of fibrous brown oxide of iron, traversing gneiss. The iron is ramous or stalactical, and occurs at the depth of 12 feet, mixed with quartz, &c.—According to Karsten, Native iron is found at Kamsdorf in Saxony, disseminated in brown oxide of iron, and mingled with sparry iron and sulphate of barytes. Klaproth found in it iron 92.5, lead 6.0, copper 1.50. Also near Steinbach, in brown garnets; and near Eibenstock in a vein, containing brown hematite and clay.—Also in Poland.*

* Some mineralogists still doubt in regard to the localities at Kamsdorf and Eibenstock.

Native Volcanic Iron has been observed in the department of Puy de Dome, France, in the lava and scoria of Mount Gravenoire.

Pseudovolcanic Steel has also been found at La Bouiche, in the department of Allier, France, near a coal mine, formerly in a state of combustion.

SUBSPECIES 1. METEORIC NATIVE IRON. JAMESON.

Fer natif meteorique. Haüy. Meteoreisen. Hausmann. Meteoric Native Iron. Aikin. Phillips.

Its color is pale steel gray, inclining to silver white, like that of platina; its surface, however, is usually rendered brown by oxidation. It has been observed in octahedral crystals, and globular; but most frequently it occurs in amorphous masses. These masses, sometimes nearly or quite compact, usually contain minute pores or cells, by which their specific gravity is sometimes reduced from 7.57 to 6.48. It is malleable, flexible, and has a metallic lustre.

Meteoric iron is less easily oxidated, than common forged iron. It is usually, perhaps always, alloyed with nickel. In a specimen from Agram, Klaproth found iron 96.5, nickel 3.5. Another from Mexico yielded him iron 96.75, nickel 3.25. It sometimes contains 10 per cent. of nickel. Some specimens contain a little chrome; and, according to Stromeyer, cobalt is sometimes present.—Some masses contain minute quantities of carbon, or exist even in the state of steel.

It is undoubtedly the nickel, which renders Meteoric iron whiter, more malleable and tenacious, and less easily oxidated, than common iron.

Meteoric iron is usually found on the surface of the earth in loose, insulated masses, often very large, and at a great distance from mines of iron. In one instance, hereafter mentioned, it has been seen falling from the atmosphere.—Many examples of Meteoric iron, from the commencement of the Christian era to the present time, are enumerated by writers. According to Pliny, a mass of spongy iron fell from the atmosphere in Lucania 56 years before Christ.

The following are some of the more striking examples.

1. A mass, found by Pallas in Siberia, near the mountains of Kemir, and not far from the river Jenisei. This mass, weighing about 1600 pounds, is very malleable and white. Its interior contains numerous cells, filled with a yellowish, transparent, vitreous substance, capable of scratching glass, and somewhat resembling olivine in composition. It was found at the surface, near the top of a mountain, which embraces a vein of magnetic oxide of iron; but there was no appearance of scorice in the vicinity. This mass, now preserved in the Academy of Sciences at St. Petersburg, is composed of metallic iron 90.54, nickel 9.46. (CHILDREN.)

2. Another mass, weighing 30,000 pounds, was found near St. Jago del Estero, in the province of Tucuman, in South America. It was partly buried in argillaceous earth in the midst of an extensive plain, which contains neither strata nor masses of any other minerals.—It is compact near the surface, and cellular in the interior; but its cells do not contain any vitreous substance, like those of the Siberian iron. Its surface is indented. (*RUBIN DE CELIS.*) It contains about 10 per cent. of nickel.

3. A mass in the Desert of Sahara in Africa. It contains 4 per cent. of nickel.

4. A mass, now in the Imperial cabinet at Vienna. It was brought from Heraschina, near Agram, in Croatia, where it fell from the atmosphere in 1751; it appeared in the air, like a globe of fire. This mass contains iron 96.5, nickel 3.5. (*KLAPROTH.*)

5. For our knowledge of this example of Native iron we are indebted to Col. Gibbs, for whose personal exertions and general patronage, mineralogy is already under numerous obligations.

This mass he observed at Bithbourg, in the Department des Forets, in France.—It is perfectly compact, and in some parts gives fire with steel, while in others it is softer. Its weight is estimated at 2500 pounds.—It contains nickel.

6. A mass, found near Red River in Louisiana; and now in the cabinet of Col. Gibbs. The form is irregular, its length being 3 feet 4 inches and its greatest breadth 2 feet 4 inches; its weight exceeds 3000 pounds. Its surface, covered with a blackish crust, is deeply indented, and its specific gravity is 7.40. It is very malleable and compact; but is unequally hard, some parts being easily cut by a chisel, while others have nearly the hardness of steel. It contains nickel, and probably a little carbon; and is less easily oxidated, than purified iron.—This mass is rendered extremely interesting by the octaedral crystals, which have been discovered in its interior by Col. Gibbs. These crystals may be easily cut by a knife, and exhibit striæ, like those of magnetic iron. The largest is more than half an inch in length.

The two last mentioned examples differ from those of Siberia and South America by their compact texture, unless it should appear, that they contain cavities in their interior.

7. Similar masses have been found in Mexico and Peru;—that of Durazzo is said to weigh 40,000 pounds, and to contain nickel.

8. A mass in West Greenland, about 30 miles from the shore of Baffin's Bay, made known by the late expedition under Capt. Ross. It contains somewhat more than 3 per cent. of nickel. (*BRANDE.*) The Esquimaux have employed this iron for knives.

9. In Brazil, 50 leagues from Bahia, is a mass weighing about 14,000 pound and having a texture somewhat crystalline. It contains iron 96.1, nickel 3.9. (*WOLLASTON.*)

10. A mass, found in Africa by Barrow, about 200 miles from the Cape of Good Hope. It contains about 10 per cent. of nickel. (*TENNANT.*)

11. Native iron, in small masses, and alloyed with nickel, exists in aerolites, or in those stony substances, which are known to have fallen from the atmosphere.

It seems almost certain, that these masses of Native iron must have proceeded from volcanoes, or fallen from the atmosphere. There appears, however, to be a strong resemblance in many of their physical characters, as well as in their composition; and the fact, that the Native iron from Croatia, &c. actually fell from the atmosphere, seems to indicate an atmospheric origin for the whole.—This opinion is confirmed by an examination of those aerolites, which have fallen from the atmosphere at different times, and in different places. They all contain metallic iron, and this iron embraces nickel. Indeed these aerolites sometimes contain a hard substance, not much unlike that in the cavities of the Siberian iron.

Mr. Sowerby, an English mineralogist, has presented to the Emperor Alexander, a sword 2 feet long, and $1\frac{3}{8}$ inch wide, hammered at a red heat from the African meteoric iron No. 10. He received in return a ring set with diamonds, and inclosing an emerald in the centre.

SPECIES 2. ARSENICAL IRON. PHILLIPS.

Fer arsenical. Haüy. Brongniart. Arsenik Kies. Werner. Hausmann. Arsenical Pyrites. Jameson. Arsenical Pyrites or Marcasite. Kirwan. La Pyrite arsenicale. Brochant. Mispickel. Aikin.

Its true color is between tin and silver white, but it is often tarnished with shades of yellow, &c. It gives fire with steel more or less freely, and the sparks are attended by a little train of white smoke, having the odor of garlic; indeed the same odor is produced by friction against a hard body.—It is not, in general, very easily broken, and its fracture is almost always uneven; its lustre is metallic and somewhat shining. Its specific gravity varies from 5.60 to 6.52.

Arsenical iron is often in crystals; and the primitive form, under which it sometimes appears, is a four-sided prism with rhombic bases, whose obtuse angles are $111^{\circ} 18'$. This prism is sometimes terminated by diedral summits (Pl. V, fig. 4.), whose faces stand on the acute lateral edges; these faces, which meet under an angle of $154^{\circ} 56'$, are usually striated parallel to the edge of the termination or bevelment;—sometimes the edges of each summit are truncated.—Sometimes each obtuse solid angle is truncated.—Sometimes the prism is very short, and its two diedral summits nearly meet.—Sometimes also the crystals are acicular. The primitive form exhibits several other modifications.

Arsenical iron also occurs in amorphous masses, either compact, or composed of prismatic distinct concretions, which sometimes terminate in crystals.

(*Chemical characters.*) Before the blowpipe, on charcoal, the oxide of arsenic is volatilized in the form of a white smoke, exhaling the odor of garlic, and a brownish oxide of iron remains. It contains, according to Lampadius, iron 58.9, arsenic 42.1 ;=101. Berzelius obtained iron 45.46, arsenic 54.55.

(*Distinctive characters.*) This mineral resembles arsenical cobalt; but the latter does not give sparks with steel, it tinges borax blue, and, when immersed in nitric acid, begins to effervesce much quicker than arsenical iron.—The compact texture of arsenical iron will serve to distinguish it from gray cobalt and antimonial silver, both of which have a foliated structure.—Its color, and its odor, when struck, distinguish it from sulphuret of iron. It is, however, hardly possible to define limits between arsenical iron and arsenical sulphuret of iron.

(*Geological situation and Localities.*) This species is usually found in primitive mountains, where it occurs in metallic veins or beds in gneiss, micaceous, argillaceous, or chlorite slate, &c. and is sometimes disseminated in other minerals. Its gangues are quartz, carbonate and fluuate of lime, &c. It is often associated with the oxide of tin, the sulphurets of lead and iron, pyritous copper, magnetic iron, &c.—It sometimes occurs in transition and even secondary rocks.

This ore is found in Bohemia, Saxony, Cornwall, &c.

In the *United States*. In *New York*, Orange County, at Warwick. (*SCHAEFFER.*)—In *Massachusetts*, near Boston, sometimes prismatic, in argillite, &c. (*GODON.*)

It is seldom explored as an ore of iron; but is employed to furnish the white oxide of arsenic, and also to prepare the sulphuret of arsenic.

SUBSPECIES 1. ARGENTIFEROUS ARSENICAL IRON. *PHILLIPS.*

Fer arsenical argentifere. Haüy. Brongniart. Weissert. Werner. Argentiferous arsenical pyrites. Kirwan. Jameson. Argentiferous Mispickel. Aikin.

It is whiter than the common arsenical iron, being more decidedly silver white; but it is usually tarnished with a shade of yellow. It has, in general, less lustre and a finer grain than pure arsenical iron. It is sometimes in acicular crystals, but seldom in masses of any considerable size.

A specimen from the Harz yielded Klaproth iron 44.25, arsenic 35.0, silver 12.75, antimony 4.0 ;=96.

It is a rare ore, and usually accompanies common arsenical iron.—At Freyberg and Braunsdorf in Saxony, it is explored as an ore of silver.

Arsenical iron sometimes contains a little cobalt or gold.

SPECIES 3. SULPHURET OF IRON.

Fer sulfuré. Haüy. Brongniart. Schwefelkies. Werner. Hausmann. Martial pyrites. Kirwan. La pyrite sulfureuse. Brochant. Iron Pyrites. Phillips.

Pyrites. Iron Pyrites.

Its color is usually bronze yellow, sometimes passing to pale brass yellow, or steel gray, or even into brown. It has nearly or quite the hardness of quartz, and almost always gives fire with steel, exhaling the odor of sulphur. Its texture is sometimes compact, and sometimes fibrous; its fracture is commonly uneven, sometimes more or less conchoidal, or nearly even. Its powder, obtained by a file, is usually blackish. Its specific gravity extends from 4.70 to 5.00. It sometimes feebly moves the magnetic needle. (*HAÜY.*)

Sulphuret of iron occurs in small amorphous masses, or presents some imitative form, and is very frequently crystallized. The primitive form of its crystals is probably a cube, of which M. Haüy has described various modifications.

1. A cube;—this is often truncated on all its angles, and sometimes so deeply, that the truncating faces touch or even intersect each other.—It is often elongated into a parallelopipedon. These cubic crystals are sometimes extremely beautiful.

2. A striated cube (Pl. V, fig. 5.);—the striæ on any one face are perpendicular to those on the adjacent faces. Very frequently the centre of the faces is a little prominent.

3. A cube, truncated on all its edges. (Pl. V, fig. 6.)

4. A cube, in which each solid angle is terminated by a three-sided pyramid, the vertex of which is sometimes truncated.—In fine, this cube is so modified by additional faces, that one variety of form, when complete, presents 134 faces, the greatest number hitherto observed on any crystal.

5. A dodecaedron with pentagonal faces, equal and similar. Six of its edges, or six of its angles are sometimes truncated.

6. An icosaedron (Pl. V, fig. 7.), presenting eight equilateral, and twelve isosceles, triangles. Six of its edges are sometimes truncated.

7. A solid, bounded by 24 faces, each of which is a trapezium.

8. A solid, bounded by 30 faces (Pl. V, fig. 8.), of which six are rhombs, parallel to the faces of the cubic nucleus, and the remaining 24 are trapeziums.

9. An icosaedron, of which each face bears a low triangular pyramid: (Pl. V, fig. 9.)

10. An octaedron, sometimes cuneiform, and sometimes with edges and angles variously modified. (See Pl. V, fig. 10.)

These crystals, sometimes large, are often small; they are frequently very perfect, with surfaces highly splendid.

(*Chemical characters.*) Before the blowpipe it exhales a strong odor of sulphur, and yields a brownish globule, obedient to the magnet; and, by continuing the heat, it is converted into a blackish scoria. It is composed of iron* and sulphur; for the proportions of which see the several varieties. Certain specimens from Peru are said to contain carbon.—It is subject to decomposition, by which it is converted into a brown oxide or sulphate of iron.

Some varieties of the Sulphuret of iron are decomposed, and yield the sulphate of iron much more readily than others; and this difference is by Mr. Hatchett attributed to a small quantity of oxygen, originally combined with the sulphur.

Sulphuret of iron sometimes contains small quantities of gold, silver, copper, arsenic, or titanium; and may thus be distinguished as *auriferous* sulphuret of iron, &c. When such Pyrites decompose, the gold, being incapable of oxidation, is left naked.—The striated cubes often contain gold.

(*Distinctive characters.*) It sometimes resembles pyritous copper; but the latter has a more lively yellow, and very often exhibits irised colors, which but seldom appear on sulphuret of iron; pyritous copper is less hard, and rarely and with difficulty gives fire with steel; in fine, the scoria, obtained by the blowpipe from pyritous copper, renders ammonia blue.—When Sulphuret of iron is free from arsenic, it may be distinguished from arsenical iron by its color, and its sulphurous odor before the blowpipe.

Var. 1. COMMON SULPHURET OF IRON OR PYRITES.* *AIKIN.* Its color is bronze yellow, sometimes approaching pale brass yellow, or steel gray; it is sometimes tarnished with shades of red, brown, &c. Its fracture is usually uneven, with a metallic lustre somewhat shining; sometimes it is conchoidal with a very high lustre.

Its crystals have the forms already described; and it is frequently amorphous.

Sometimes it appears in membranes or *dendritic* branches, which are often embraced between layers of slaty minerals.

In some cases, the crystals are so grouped as to resemble a spear, forming the *Sparkies* of Werner, or *Spear Pyrites* of Jameson.

Sulphuret of iron also presents *concretions*, whose forms may be globular, cylindrical, reniform, &c. Their surface is sometimes rough or scaly.

Three crystals, analyzed by Hatchett, yielded iron 47.30 to 47.85, sulphur 52.15 to 52.70.

* Some mineralogists have supposed the iron in this mineral to exist in the state of an oxide; but there seem to be better reasons for believing it to be in a metallic state.

† Gemeiner schwefelkies. *Werner.* Hexahedral iron Pyrites. *Jameson.* Marcasite of some.

CAPILLARY PYRITES. This occurs in very delicate needles, which sometimes cross each other in various directions.

CELLULAR PYRITES.* *JAMESON.* This subvariety presents little cells, which are sometimes hexangular, &c. and lined with minute crystals. Its color inclines strongly to steel gray.

(*Localities.*) Of these we select but few. In the *United States.* In *Ohio*, it occurs in globular masses, nearly brass yellow, varying from the size of a pea to several inches in diameter, and generally in clay. (*ATWATER.*)—In *New York*, at Kingsbridge, in small dodecahedrons with pentagonal faces in primitive limestone;—also in the Haverstraw Mountains, forming beds in greenstone. (*PIERCE & TORREY.*)—In *Maine*, at Brunswick, Winthrop, Fairfax, &c. often in argillite and mica slate.

2. RADIATED SULPHURET OF IRON.† Its color is usually a pale bronze yellow, more or less inclining to steel gray, and sometimes passing even to tin white on the fresh fracture. It is liable to tarnish, and may then become brass yellow, &c. or exhibit variegated colors.

Its crystals are usually octaedrons, sometimes elongated, and sometimes with truncated angles. In some cases four of the solid angles are truncated by rhombic faces, and the other two angles by squares.—Sometimes the edges and two opposite solid angles of the octaedron are truncated.—It occurs also in four-sided prisms with rhombic bases of $106^{\circ} 36'$ and $73^{\circ} 64'$. The extremities of this prism are sometimes bevelled, and even further modified. Indeed, according to Haüy, the aforementioned rhombic prism is the primitive form of these crystals. Of course, in a crystallographical arrangement of minerals, Radiated Pyrites would form a distinct species.

But more frequently the form of this variety is globular, botryoidal, reniform, cylindrical, stalactical, &c. Its surface is often rough, and sometimes distinctly presents the solid angles of octaedral crystals. Its masses have a fibrous structure.—When the form is spherical, the fibres diverge or radiate from the centre, and, when nearly cylindrical, from the axis. It sometimes presents curved lamellar concretions, traversing those, which are granular.—It is easily broken, and has an uneven fracture, with a glistening lustre.

A mean of two analyses by Hatchett gives iron 46.03, sulphur 53.97. According to Berzelius, the composition of the Radiated or white Pyrites is precisely the same as that of the common variety.

This variety is rarer, and more liable to decomposition, than the common Pyrites, and capillary crystals of sulphate of iron sometimes

* Zellkies. *Werner.*

† Strahlkies. *Werner.* Radiated Pyrites. *Jameson.* Fer sulfuré radié. *Haüy.* Brongniart. Strahliger Wasserkies. *Hausmann.* White Pyrites. *Aikin.* Radiated iron Pyrites. *Phillips.*

appear on its surface. Sometimes also it passes by decomposition to an oxide of iron.

COCKSCOMB PYRITES.* *JAMESON*. It occurs in plates, or rather in groups of compressed or flattened octaedrons, which present *indented* edges, somewhat resembling the crest of a *cock's comb*. Sometimes the prismatic crystals are thus compressed and indented; and sometimes the edges of the plates are rounded.

This subvariety is found in the mines of Derbyshire, Saxony, &c.

(*Localities.*) Radiated Pyrites sometimes occurs in veins of lead and silver; and sometimes in chalk, clay, and marl.—It is found crystallized near Freyberg in Saxony; in Bohemia; France; Cornwall; Derbyshire, &c.

In the *United States*. In *New York*, at New Concord, in spheroidal masses. (*EATON*.)—Also at Rhinebeck in Dutchess County.—In *Maine*, at Harpswell, in globular and botryoidal masses.

3. HEPATIC SULPHURET OF IRON.† This embraces those varieties of Sulphuret of iron, which are susceptible of a peculiar decomposition, by which the sulphur is more or less disengaged. During this process, the Pyrites is converted, either entirely or in part, into a compact oxide of iron of a *liver*‡ brown color; but still retains its original forms. Its hardness and specific gravity are somewhat diminished, and its lustre disappears. This decomposition commences at the surface, and gradually extends to the centre. In fact, portions of Pyrites, not decomposed, have been observed near the centre of masses of a reddish oxide of iron.

The decomposition, of which we here speak, is of a very different nature from that, by which the Sulphuret of iron is converted into sulphate of iron (copperas.) Indeed the cause and manner of this decomposition have not yet been well explained.

This variety presents nearly all the forms of the common Sulphuret of iron. Sometimes also the radiated variety undergoes a similar alteration.

It is usually found in veins, containing other ores, in primitive rocks.

In the *United States*. In *New Jersey*, near Sparta, in masses, which break into large regular tables. (*PIERCE & TORREY*.)—In *New York*, on Staten island—also at Anthony's Nose, in large quantities, mingled with common pyrites and phosphate of lime. (*PIERCE & TORREY*.)

(*Geological remarks.*) Few minerals are more universally diffused, than Sulphuret of iron, especially the common variety, which extends from primitive rocks to alluvial earths. Indeed there are but few earthy or saline simple minerals, occurring in considerable masses, in which it is not sometimes more or less interspersed. But though usually

* Fer sulfuré blanc dente é. *Hauy*. Kammkies. *Werner*.

† Leberkies. *Werner*. Hepatic Pyrites. *Jameson*. *Aikin*. *Phillips*. Fer sulfuré epigene. *Hauy*. Dichter Wasserkies. *Hausmann*. ‡ Hence the term *Hepatic*, from the Latin, *hepar*, liver.

disseminated in other minerals, or mingled with other ores, it sometimes constitutes almost the only ore in veins of quartz, carbonate of lime, &c.

There is scarcely a metallic vein or bed, which does not contain Pyrites. In coal also it is not uncommon.—In volcanic productions, however, it is rare; and, according to Brongniart, has seldom been observed in the sulphate or phosphate of lime, or in anthracite.

Sulphuret of iron sometimes invests the crystals of other substances;—and sometimes it is *pseudomorphous*, constituting the substance of the cornu ammonis, belemnite, &c.—In other cases it penetrates fossil wood.—Flints and other hard stones, immersed for some time in certain stagnant waters, become invested with a thin coat of Pyrites.

Although Pyrites has been found in all the meteoric stones, which have been examined, we are indebted to Col. Gibbs for the discovery of two cubic crystals of Pyrites in the meteoric stone, which fell at Weston (Con.) in 1807. One of these crystals is about $\frac{2}{3}$ of an inch in diameter. (Bruce's Min. Jour. v. i.)

(*Localities.*) Some of the more important localities have been mentioned under the several varieties.

Auriferous Pyrites occurs in the gold mines of Beresof in Siberia; also in Hungary, Norway, France, &c.

Argentiferous Pyrites is found in Saxony; and abundantly in New Spain.

Titaniferous Pyrites occurs at St. Gothard, in small, brownish masses in slaty talc with carbonate of lime, &c. (*Haur.*)

(*Uses and Remarks.*) This substance, though never employed to furnish iron, is still a valuable ore. Its sulphur is sometimes extracted by sublimation. But it is chiefly valued for the sulphate of iron, (copperas), which it affords by decomposition;—a change, which some varieties undergo much more readily than others. In this process, the sulphur receives oxygen from the air, or from moisture, and is converted into sulphuric acid. This acid combines with the oxide of iron, thus forming sulphate of iron, which is extracted by lixiviation, evaporation, and crystallization. Sometimes this decomposition is spontaneous, or effected by merely exposing the Pyrites to air and moisture; but some varieties must be previously roasted.—The sulphate of iron often appears on the surface of the Pyrites, or the mineral, which contains it, in yellowish or white silky efflorescences, sometimes mixed with sulphate of alumine.

Whenever large masses of Pyrites undergo decomposition, a great degree of heat is produced; and to this heat may be attributed the spontaneous combustion of certain coal mines, and the elevated temperature of warm springs. In fine, this decomposition often takes place in cabinets.

In the *United States*; manufactories of the sulphate of iron, or copperas, are established in *Tennessee*.—In *Maryland*, about 20 miles from Baltimore, where the Pyrites is extremely abundant, and readily efflorescent.—In *Ohio*, near Zanesville on the Muskingum;—also at Steubenville. The sulphuret is found in argillaceous slate or shale, belonging to the coal formation. (*ATWATER*.)—In *New Jersey*.—In *Vermont*, at Strafford and Shrewsbury.—At Strafford this ore is found abundantly. Near the surface of the mine, the Pyrites embraces twigs and roots of vegetables, beech burs, and the fruit or cones of the hemlock. At a greater depth, it becomes more solid and compact. The ore is broken into small fragments, and thrown into heaps 6 or 8 feet high, for one year, in which time decomposition takes place, and the Sulphate of iron is formed. During this process a gas rises about 10 or 12 feet high, and destroys the leaves of trees in the vicinity. These works have furnished three tons of copperas in 2 days; but the low price of this article at present has much diminished the quantity. (*W. ALLEN*.)—In *Maine*, at Winthrop.

Pyrites was formerly employed for the same purpose as flint; and hence probably the origin of the name.

SUBSPECIES 1. MAGNETIC SULPHURET OF IRON.

Fer sulfuré magnétique. *Brongniart*. Fer sulfuré ferrifère. *Hauy*. Magnetkies. *Werner*. *Hausmann*. Magnetic Pyrites. *Kirwan*. *Jameson*. *Aikin*. La Pyrite magnétique. *Brochant*. Magnetic iron Pyrites. *Phillips*.

Magnetic Pyrites.

The most remarkable character of this subspecies is that of moving the magnetic needle, and of constituting a permanent magnet.—Its color is bronze yellow, more or less mingled with copper red, and sometimes it is pinchbeck brown, or even gray; its surface has often a dull brown or variegated tarnish.

It is almost always amorphous; its masses are easily broken, and have an uneven or imperfectly conchoidal fracture; its lustre is metallic, but variable. Its specific gravity is between 4.4 and 4.6.

Its structure is sometimes foliated; and it is said to occur in cubes, either perfect, or elongated; and sometimes modified on the edges or angles.

Before the blowpipe it exhales the odor of sulphur, and melts into a blackish globule, obedient to the magnet. It contains iron 63.50, sulphur 36.50. (*HATCHETT*.)

Hauy considers this subspecies a common Sulphuret of iron, mixed with a little metallic iron.—Magnets, made with this Sulphuret, are said to be more durable, than others.

(*Geological situation and Localities*.) This ore has hitherto been found, almost exclusively, in primitive rocks, such as mica slate, gneiss,

granite, greenstone, limestone, &c. It is disseminated, or exists in beds. It is generally associated with the common pyrites, and other metallic sulphurets, magnetic oxide of iron, garnets, hornblende, &c. In Bohemia, its beds sometimes lie between gneiss and greenstone, and sometimes between gneiss and limestone.

In the *United States*. In *Pennsylvania*, near Philadelphia, in small quantities, in hornblende rocks. (*LEA*.)—In *New York*, in the Highlands;—it frequently occurs also in the iron mines on the west side of Lake Champlain. (*GIBBS*.)—In *Connecticut*, at Brookfield, in granite; it is abundant, highly magnetic, decomposes rapidly in the air, and furnishes excellent copperas—also at Huntington, in the vein, which contains native bismuth. (*SILLIMAN*.)—Also near Woodbury, in gneiss. (*EATON*.)—In *Massachusetts*, near Boston.—In *Maine*, at Brunswick, in granular limestone, with common pyrites in cubes, green talc, &c.

SUBSPECIES 2. ARSENICAL SULPHURET OF IRON.

Fer sulfuré arsenifère. *Hauy*. Arsenical Pyrites. *Aikin*. Arsenical iron Pyrites. *Phillips*.

This is a sulphuret of iron, containing variable proportions of arsenic, which may be discovered by its odor, when the mineral is struck or heated. It is often difficult to distinguish it from pure Sulphuret of iron, on one side, and from arsenical iron, on the other, between which extremes there seem to be numerous intermediate shades. In general, with an increase of arsenic, the yellow tinge of the Sulphuret of iron diminishes and passes to gray.

It is frequently associated with common Pyrites and arsenical cobalt.

In the *United States*. In *New York*, it occurs in the Highlands.—In *Connecticut*, at Derby, Middletown, Chatham, &c. at the last place it is associated with arsenical cobalt. (*SILLIMAN*.)

SPECIES 4. MAGNETIC OXIDE OF IRON.

Fer oxidulé. *Hauy*, *Brongniart*. Magneteisenstein. *Werner*, *Hausmann*. Magnetic iron stone. *Kirwan*. Le Fer magnétique, *Brochant*. Octahedral Iron ore. *Jameson*. Oxidulated Iron. *Phillips*. Magnetic Iron ore. *Aikin*.

Its color is iron black, usually darker than forged iron, but sometimes passes to bluish or steel gray. Its powder is always nearly or quite black. Its surface is liable to tarnish.

Although its hardness is very considerable, it is in general very easily broken, and some varieties are friable. It sometimes gives fire with steel.

This ore always acts more or less on the magnetic needle, and sometimes attracts filings of iron. Its specific gravity varies from 4.20 to 5.20.

The primitive form of its crystals is a regular octaedron, under which it frequently appears. This octaedron, when broken, often presents laminæ parallel to its faces, and its surface is sometimes striated parallel to the sides of the faces. Sometimes also it is cuneiform and

lengthened ; and sometimes truncated or bevelled on all its edges.—Each summit of the primitive octaedron is sometimes terminated by a four-sided pyramid.—Another form is a dodecaedron with rhombic faces, often striated in the direction of the longer diagonals of the faces.—It also occurs in cubes, either perfect, or truncated on the angles, and sometimes elongated into parallelopipeds.—It also occurs in four-sided prisms, terminated by four-sided pyramids.—These crystals are often very regular, and sometimes large.

Sometimes this ore occurs in masses, whose structure is more or less distinctly foliated.

It has also been observed with a fibrous aspect, which in some cases, at least, is produced by the intermixture of fibres of hornblende, or by viewing the parallel edges of thin laminæ.

It also presents itself in lamellæ or plates ;—and sometimes in the state of sand.

But it most frequently occurs in compact, or granular masses, of which the granular concretions are sometimes separable by the finger. Its fracture is usually uneven, or more or less conchoidal with small cavities, and sometimes nearly even ; its lustre is metallic, but variable from splendent to glimmering.

It is insoluble in nitric acid. Before the blowpipe it becomes brown, but does not melt. According to Berzelius, it contains peroxide of iron 69, protoxide of iron 31. In an octaedral crystal, taken from steatite, Robiquet found 6 per cent. of oxide of titanium. In a specimen of the massive variety, Thomson found 3 or 4 per cent. of oxide of titanium.

Its strong action on the magnetic needle, and the black color of its powder, will serve to distinguish it from the specular oxide of iron.

*Var. 1. NATIVE MAGNET.** (Loadstone.) The magnetism of iron, or its power of moving the magnetic needle, is not destroyed by the addition of a small quantity of oxygen, and may, perhaps, continue sensible even with 30 per cent. Possibly, however, the presence of a small quantity of some combustible may be essential to the permanent magnetism of the oxides of iron.

Some of these low oxides of iron attract iron filings, and possess also a sensible polarity, by which, if the two extremities of a small fragment be alternately presented to the same pole of a magnetic needle, one extremity will attract, and the other repel, the needle. This polarity is sometimes imperceptible, unless a very feeble needle be employed ; for, when a fragment, whose polarity is very weak, is presented to a strong needle, its poles are instantly inverted, and of course it constantly attracts the needle. Hence by employing very weak needles M. Haüy has been able to observe polarity in many specimens of the

* Fer oxidulé aimantaire. Brongniart:

brown oxide of iron. Perhaps all magnetic oxides really possess polarity, though it is often extremely feeble.

It appears then, that those oxides of iron, which possess a very sensible magnetism, belong to the species, called Magnetic oxide of iron; and that those varieties, which attract iron filings and exhibit polarity in the strongest degree, constitute the variety, which is called *Native magnet*.

This variety acts very sensibly on strong needles, and easily raises filings of iron. Though sometimes crystallized, it is usually in amorphous masses, whose texture is granular, or compact, or somewhat foliated. Its color, in consequence of foreign intermixture, is sometimes brownish red or even gray.

The magnet is generally situated in the earth nearly in the direction of the meridian, that is, with its north pole toward the north; but sometimes this position is inverted.

According to the observations of Werner and Gibbs, this oxide of iron is not magnetic, while remaining at a considerable depth below the surface of the earth; but soon acquires this property after exposure to air and light.

Delicarlia in Sweden, Norway, Siberia, &c. furnish some of the strongest magnets.

In the *United States*. In *Arkansas Territory*, on the Wachitta, 15 miles below the Hot Springs, it possesses strong magnetic powers. (*SCHOOLCRAFT*.)—In *South Carolina*, Pendleton District.—In *Pennsylvania*, Chester County, at Goshen; its polarity is strong. (*MORTON*.)—In *New Jersey*, at Schooley's mountain.—In *Maine*, at Topsham, where its polarity is sometimes very strong. Sometimes the polarity of the entire crystal is feeble, while that of its fragments is very considerable.

2. IRON SAND.* *JAMESON*. This variety occurs in small octaedral or dodecaedral crystals, or in fragments of crystals, or in grains, constituting a sand. This sand has but little lustre, is strongly attracted by the magnet, and may thus be separated from other sandy particles, with which it is usually mixed.—Its color is iron black, often very dark.

This sand is not always a pure oxide of iron, but frequently embraces considerable quantities of the oxide of titanium. A specimen yielded Klaproth oxide of iron 85.5, of titanium 14.0, of manganese 0.5. It sometimes contains more than 20 per cent. of the oxide of titanium, and thus approximates in composition to the mineral, called Iserine.

It is sometimes *chromiferous*. In a specimen, composing part of the sand of the river Rhine, Koelreuter found oxide of iron 98, of chrome 2.

* Eisensand. *Werner*. Magnetic sand. *Kirwan*. Le Fer magnetique sablonneux. *Brochant*. Kor-niger Magneteisenstein. *Hausmann*. Sandy Magnetic Iron ore. *Aikin*. Titaniferous oxydulated iron. *Phillips*.

Iron sand is found on the bottom of vallies, on the banks of rivers, or on the margin of the sea; and appears to have been separated by the action of water from those minerals, which once enveloped it, such as wacke, basalt, steatite, chlorite slate, &c.—It is often mingled with iserine, to which it is nearly allied.

It is sometimes sufficiently pure and abundant to be smelted.

In the *United States*. In the *North West Territory*, near Bois brulé river, which empties into Lake Superior, where it forms a stratum one foot thick. (*SCHOOLCRAFT*.)—In *Virginia*.—In *Maryland*.—In *Ohio*, on the shore of Lake Erie, near the river Ashtabula. (*DEWEY*.)—In *Connecticut*, at West Haven, on the beach, which forms the margin of the sea shore. This sand is highly magnetic, uncommonly pure, and has very obviously proceeded from the disintegration of the chlorite slate, contiguous to the beach, and abounding with minute octaedral crystals of magnetic iron. These crystals, liberated from the slate and broken by the action of the waves, constitute the magnetic sand of the beach. (*SILLIMAN*.)—In *Rhode Island*, on Block Island. (*GIBBS*.)—In *Massachusetts*, at Gill.—Also at Montague, on the banks of the river, near the Falls. (*HITCHCOCK*.)

3. EARTHY MAGNETIC OXIDE OF IRON.* It occurs in opaque, bluish black masses, which easily yield to the knife, and are sometimes friable. Its fracture is uneven or earthy, and dull. It usually soils the fingers. Its specific gravity is 2.2.

It is found in the iron mines of Arendal in Norway; and at Eisenfeld in Siegen.

(*Geological remarks on the Species*.) Magnetic oxide of iron is most frequently found in primitive mountains, where it exists in granite, gneiss, mica slate, chlorite slate, serpentine, greenstone, and rocks abounding with hornblende. It has been observed also in transition and even secondary rocks.

It is sometimes disseminated, or in veins, but more frequently in beds, which are sometimes very large. In some instances, it constitutes the greater part of whole mountains, as that of Taberg in Sweden.

It is associated with the sulphuret of iron both common and magnetic, arsenical iron, sulphuret of copper, oxide of titanium, &c. also with garnets, carbonate of lime, hornblende, epidote, coccolite, augite, &c.

(*Localities*.) Of foreign localities Sweden is the most important. In Smoland, the Taberg Hill is composed in a great degree of this ore in greenstone, resting on gneiss. In the island of Uto, it forms a thick bed in gneiss. At Dannemora, the most important mines of this ore in Europe, it forms a bed, several hundred feet thick, also in gneiss.—

* Earthy magnetic Iron ore. *Jameson*. *Aikin*. Fer oxydulé fuligineux. *Haüy*. Ochriger Magnet-eisenstein, *Hausmann*.

In Norway, at Arendal, it occurs in beds from 4 to 60 feet thick in gneiss, with augite, epidote, garnet, &c.—In Lapland, at Gellivara, in large beds.—The mines of Cogne, in Piedmont, are in serpentine, embraced in strata of mica slate.

In the *United States*. In *North Carolina*, in the western part of the State.—In *Maryland*, near Baltimore, &c.—In *Pennsylvania*, Chester County, and on Edge Hill in Buck's County. (*WISTER*.)—At Chestnut Hill, 10 miles from Philadelphia, on Wichicon creek, it occurs in regular octaedrons from $\frac{1}{16}$ to $\frac{1}{2}$ inch in diameter in talcose rocks. (*LEA*.)—In *New Jersey*, in the primitive mountains, which extend from N. E. to S. W. through the northern parts of the state to the vicinity of the Delaware river. At Suckasunny, the bed is nearly perpendicular, and has been worked to the depth of 100 feet. The ore in the upper part of the bed is magnetic, and possesses polarity, while that from the lower part has no magnetism, until after exposure to the atmosphere and light. (*GIBBS*.)—In Sussex County, its gangue is sometimes the red oxide of zinc. (*BRUCE*.)—In *New York*, it occurs in immense quantities on the west side of Lake Champlain, in granitic mountains; the ore is in beds from one to twenty feet thick, and generally unmixed with foreign substances;—also in the Highlands; in fact, large beds of this ore extend with little interruption from Canada to the vicinity of New York; the ore at Crown Point is most esteemed. (*GIBBS*.)—In *Rhode Island*, it occurs crystallized in serpentine. (*GIBBS*.)—In *Massachusetts*, at Williamstown, in octaedrons in mica slate. (*DEWEY*.)—Also at Middlefield, in octaedral crystals in mica slate. (*EATON*.)—At Woburn, it is associated with pyritous copper in a vein, traversing greenstone. (*J. F. & S. L. DANA*.)—In *Vermont*, at Somerset, in considerable quantities with pyrites, &c. (*J. A. ALLEN*.)—In *New Hampshire*, near Franconia, Grafton County, 8 miles east from Connecticut river; the bed, from 5 to 8 feet thick, is contained in gneiss; the ore is compact, or fine grained, and bluish gray, and is accompanied by garnet, epidote, and hornblende. (*GIBBS*.) This bed has been explored at least 200 feet in a horizontal line, and at the greatest depth is about 90 feet below the surface. The ore generally yields from 50 to 60 per cent. (*HALE*.)—Also at Amherst, in rhombic dodecaedrons in granite, or in veins of feldspar, traversing granite. (*J. F. DANA*.)—In *Maine*, at Topsham, Lincoln County, disseminated in granite; it is generally in octaedral crystals varying in size from that of a pin's head to 2 inches diameter;—also at Paris and Buckfield in Oxford County.

(*Remarks*.) Magnetic oxide of iron sometimes yields from 80 to 90 per cent. of metallic iron; but from some of its ores not more than 50 or 60 per cent. is obtained. It furnishes the best of bar iron, and

the Swedish, so much esteemed for the manufacture of steel, is obtained from this ore. Its bar iron, however, is sometimes *red short*.

SPECIES 5. SPECULAR OXIDE OF IRON.

Eisen glanz. *Werner. Hausmann.* Specular iron. *Kirwan. Jameson. Phillips.* Le Fer speculaire. *Brochant.* Fer oligiste. *Haüy. Brongniart.* Variety of Red iron ore. *Aikin.*

Its usual color is steel gray, light or dark, sometimes passing into iron black, and sometimes with a tinge of red. Its surface is often beautifully tarnished with azure blue, or is pavonine, irised, or like tempered steel, or reflects even a green light. But however dark its external color, its streak and powder are a dark cherry red, or blackish red; and its powder, rubbed on paper, leaves a brownish red trace. Indeed the edges of very thin fragments sometimes transmit a deep blood red light. Its surface has a metallic lustre, which is often highly splendid.

It has a very feeble action on the magnetic needle, and does not raise iron filings, even in those cases, in which it possesses a sensible polarity; its powder is slightly affected by the magnet.

It is sufficiently hard to scratch glass, and breaks with difficulty in some varieties, while in others it is very brittle. Its specific gravity usually lies between 4.67 and 5.21.—When crystallized, its structure is foliated in directions parallel to the planes of the primitive form. Its fracture is uneven or conchoidal with small cavities, and sometimes foliated; its lustre is metallic, sometimes splendid, but more frequently somewhat shining.

Specular iron is frequently in crystals, whose primitive form, which it sometimes presents, is a rhomb slightly acute; its angles being nearly 93° and 87° . These angles, when measured on planes obtained by mechanical division, are, according to Phillips, $86^\circ 10'$ and $93^\circ 50'$. Of this nucleus, which is most easily obtained from certain massive varieties, Haüy has described not less than 15 modifications. Some of its secondary forms differ extremely from each other, as well as from the primitive. The following are some of the more common.

1. Sometimes two solid angles of the primitive, diagonally opposite, are replaced by three triangular faces.

2. A solid, contained under 24 faces (Pl. V, fig. 11.), of which six are pentagons, six are isosceles triangles, and twelve are scalene triangles. Or it resembles a cube, of which two solid angles, diagonally opposite, are terminated by three triangular faces, and all the other angles by two triangular faces.—This form is common in those beautiful crystals, which proceed from the isle of Elba, where they occur in groups, and often present a very lively and irised play of colors.

3. Another form (Pl. V, fig. 12.) consists of two hexaedral pyramids, applied base to base, with their summits deeply truncated; any two

opposite sides are inclined at the common base at nearly 121° . The summits are often truncated so near to the common base, that the crystal becomes a thin *hexagonal table*, bevelled on the edges.—This form prevails at Framont in France.

4. Sometimes the solid angles (Pl. V, fig. 13.) about the common base of the preceding form are truncated by rhombic faces.—Sometimes also the alternate lateral edges are truncated.

5. Sometimes the summits of the primitive rhomb are deeply truncated. The crystals, which belong to this variety, often have the aspect of an octaedron much compressed, or of a thin segment of an octaedron, and thus become six-sided tables or plates, surrounded by trapezoidal faces. Sometimes also the solid angles of the bevelment are truncated.—These plates or tables are most frequently found in volcanic productions; they are highly polished, brittle, and have a conchoidal fracture.

In most cases the crystals of Specular iron, unless tarnished, exhibit a very strong, metallic, external lustre, sometimes equal to that of highly polished steel; hence the term *Specular*.

Sometimes the edges and angles are so rounded, that the crystal assumes a lenticular form.

Sometimes it is in *plates* or lamellæ, whose surface is often marked by striæ, intersecting each other. These lamellæ, either straight or curved, often appear translucent, and blood red, when viewed in a strong light. They sometimes so intersect, as to form cells.

Specular iron also occurs in granular or compact masses, which are often very large.

(*Chemical characters.*) It does not dissolve in nitric acid. Before the blowpipe it is infusible, but becomes reddish. It is an oxide of iron, containing, according to Kirwan, from 24 to 30 per cent. of oxygen. It sometimes contains silex and alumine, even when crystallized.—The ore from Elba contains oxide of titanium. (*BERZELIUS.*)

(*Distinctive characters.*) Its reddish powder and feeble action on the magnetic needle distinguish it from the magnetic oxide of iron.—Gray copper and sulphuret of lead yield a black powder, and are not in any degree magnetic.

(*Geological situation and Localities.*) Specular iron usually occurs in primitive mountains, and sometimes also in transition rocks. It is sometimes disseminated in other minerals; but more frequently constitutes large veins or beds, or irregular masses, and sometimes whole mountains, as in the island of Elba. Its finest crystals are found in cavities in the interior of the massive or compact varieties.

It is accompanied by magnetic iron, red oxide of iron, quartz, &c.

Its most important localities are the isle of Elba, where it is extremely abundant;—Framont in France;—Sweden;—Norway;—Cornwall;—and Scotland.

In the *United States*. In *Maryland*, near Baltimore, in gneiss; also lamellar in chlorite. (*HARDEN*.)—In *New York*, near Lake Champlain, in primitive rocks. (*GIBBS*.)—In *Massachusetts*, at Brighton and the Blue Hills in thin laminæ in quartz. (*GODON*.)—Also at Montague, near the junction of Miller's river with the Connecticut. Its veins, sometimes 10 feet wide, traverse granite—also at Hawley. (*HITCHCOCK*.)—In *Vermont*, at Jamaica.

Specular iron frequently occurs in the fissures and other cavities of lava, often near the crater of volcanoes; and, in many cases, has evidently been sublimed by volcanic fire. It exists in highly polished and very brittle plates, or tabular crystals, bevelled on their edges.—In Auvergne, it occurs in small scales, disseminated in a porous lava.—In Stromboli, in the fissures of lava; the largest plates are 4 inches by $3\frac{1}{2}$, while others cannot be observed without a glass; they all possess polarity, although they are not affected by the magnet, unless previously reduced to fine particles. (*SPALLANZANI*.)

(*Remarks.*) When abundant, Specular iron is a valuable and profitable ore. It furnishes good iron, both cast and malleable; but the latter is said to be harder, than that obtained from magnetic iron.

It generally yields from 65 to 75 per cent.

SUBSPECIES 1. MICACEOUS OXIDE OF IRON.

Micaceous iron ore. *Kirwan*. Eisen glimmer. *Werner*. Micaceous Specular iron. *Jameson*, *Phillips*. Le Fer micacé. *Brochant*. Fer oligiste ecailleux. *Hauy*. *Brongniart*. Micaceous red iron ore. *Aikin*. Schuppiger Blutstein. *Hausmann*.

Its color is iron black or steel gray; but its streak and powder are a dark cherry red. In some specimens, however, the tinge of red is visible only under a particular incidence of light. Very thin laminæ are translucent, and sometimes appear deep blood red.

Its structure is foliated, with a shining metallic lustre; the laminæ are often curved. Its specific gravity, sometimes 5.07, is stated by Bournon at 3.96.—It is less hard, than common specular iron, is easily broken, and reduced into small shining scales; indeed the friction of the finger often detaches minute particles, which are unctuous to the touch.

It occurs in masses, composed of thin shining laminæ or scales, applied to each other, and sometimes diverging from a centre. Sometimes also it is in distinct tabular crystals.* It often slightly affects the magnet, especially when examined by double magnetism.

Its laminæ are not flexible, like those of mica; and its specific gravity is greater than that of mica or graphite.

* Bournon considers this a distinct species, in which the iron is more highly oxidated, than in common specular iron. He says the primitive form of its crystals is a cube, that its hardness and specific gravity are less, and its powder redder, than in the common variety, and that it is not magnetic.

(*Geological situation and Localities.*) It occurs in primitive mountains, sometimes on the surface of rocks, or on other ores of iron, or is disseminated; sometimes also in veins, or in beds or masses of considerable size.—It is often found in connexion with the common specular iron, and is sometimes associated with the red oxide of iron, &c. It is sometimes closely allied to the scaly red oxide of iron.

In the *United States*. In *Missouri*, Madison County, at the Narrows, near the St. Francis, in a vein traversing red granite. In Bellevue, Washington County, Micaceous iron forms a ridge from 500 to 600 feet high, and half a mile long; it is in shining laminae, and sometimes associated with red oxide of iron and quartz. (*SCHOOLCRAFT.*)—In *Virginia*.—In *Maryland*, near Baltimore, in primitive rocks. (*HARDEN.*)—In *Pennsylvania*, Montgomery County, in Upper Dublin, in hexagonal tables. (*CONRAD.*)—In *New Jersey*, near Snake Hill, north from the Rariton, in gray sandstone. (*PIERCE.*)—In *New York*, at Fort Lee, in small, shining scales, filling cavities in cellular quartz. It resembles black mica, and is neither magnetic, nor soluble in acids, unless previously heated with charcoal. (*PIERCE & TORREY.*)—In *Connecticut*, at New Stratford.—In *Massachusetts*, at Hawley.—Also at Brighton, Charlestown, &c.—In *Vermont*, at Jamaica.—In *Maine*, near Belfast.

(*Remarks.*) It is but rarely in sufficient quantity to be explored by itself. It yields about 70 per cent. of good iron.

SPECIES 6. RED OXIDE OF IRON.

Fer oxidé rouge. *Brongniart.* Rotheisenstein. *Werner.* Hausmann. Red iron ore. *Jameson.* Phillips.
La mine de fer rouge. *Brochant.* Variety of Fer oligiste. *Hauy.* Variety of Red iron ore. *Aikin.*

In this species the iron appears to be more highly oxidated, than in either of the two preceding. It is nearly or quite destitute of magnetic properties, unless examined by double magnetism. It very seldom exhibits a lustre really metallic; and has, in fact, more of an earthy, than a metallic aspect. Though never crystallized, it often presents some imitative form. Its texture is usually fibrous, or compact; but it sometimes occurs in a loose or slightly indurated state.

Its external color is red, usually more or less mixed with a shade of brown or gray; but its streak and powder are always red, most frequently blood red, sometimes with a slight tinge of brown or yellow. It is in most cases perfectly opaque. Its powder is fine, and very hard, but not rough.

Before the blowpipe, on charcoal, it grows darker, becomes magnetic, and even acquires polarity; but does not melt. It has not been satisfactorily analyzed; but appears to be nearly a pure oxide of iron, sometimes contaminated with silex, alumine, lime, or oxide of manganese.

*Var. 1. SCALY RED OXIDE OF IRON.** Its color usually varies between cherry red and brownish red, and sometimes inclines to steel gray. Its surface is sometimes irised. Its lustre is glossy, and, in some instances, nearly metallic.—It is unctuous to the touch, soils the fingers strongly, and leaves on them numerous, little spangles, which closely adhere.

It occurs in crusts or masses, more or less friable, and composed of minute scales.—It has also been observed in little translucent plates, of a lively red, united in globular masses, in cavities of the red hematite. (*HAUY.*)

This variety appears to differ but little from micaceous oxide of iron, into which it passes. A specimen, analyzed by Henry, yielded iron 66.0, oxygen 28.5, silex 4.25, alumine 1.25.

(*Geological situation and Localities.* Though usually in primitive mountains, it has been observed in secondary rocks, and even upon coal. Rarely in masses, it usually appears in crusts on other minerals, as specular and sparry iron, &c. and is even intermixed with the micaceous oxide. It is often associated with the other varieties of the red oxide of iron, quartz, &c.—At Sahla, in Henneberg, it occurs in sufficient quantity to be smelted, and yields good iron. (*JAMESON.*) In England at Ulverstone, &c.

In the *United States*, it is found in *Pennsylvania*, at the Perkiomen lead mine. (*CONRAD.*)—In *Connecticut*, at Kent, in primitive rocks. (*GIBBS.*)

2. RED HEMATITE.† *JAMESON. KIRWAN.* Its color is usually brownish red, often with a tinge of steel gray. It sometimes inclines to blood red, or even steel gray, especially at the surface; indeed the surface is sometimes bluish gray with considerable lustre. Its streak and powder, however, always appear nearly blood red.

Its structure is always very distinctly fibrous; and the fibres, though sometimes nearly parallel, almost always diverge from one point in each concretion toward the circumference; sometimes they even radiate from a centre. Its lustre is either glistening and slightly metallic, or, when the fibres are very delicate, it resembles that of silk.

It is solid, and has sometimes almost the hardness of quartz. By friction against a hard body, it often acquires a lustre nearly metallic. Its fragments sometimes resemble splinters of wood.

It is seldom amorphous, but almost always in concretions, which are usually reniform, sometimes globular, botryoidal, stalactical, or cylin-

* Fer oxidé rouge luisant. *Brongniart.* Rother eisenrahm. *Werner.* Scaly Red Iron ore. *Jameson. Phillips.* Fer oligiste luisant. *Haüy.* Red Scaly Iron ore. *Aikin.* Schaumiger Rotheisenstein. *Hausmann.*

† Fer oxidé rouge hématite. *Brongniart.* Rother glaskopf. *Werner.* L'Hématite rouge. *Brochant.* Fer oligiste concretionné. *Haüy.* Fasriger Rotheisenstein. *Hausmann.* Red Hematite. *Aikin.* Fibrous Red Iron ore. *Phillips.*

drical. The cylinders are sometimes aggregated. In fact, its larger masses are usually composed of smaller concretions, which are sometimes both concentric and lamellar.—Its specific gravity extends from 4.74 to 5.00.

A specimen, analyzed by Daubuisson, yielded oxide of iron 94, water 2, silex 2;= 98.

(*Geological situation and Localities.*) It occurs chiefly in primitive mountains, but sometimes in transition and secondary rocks. It is found in veins, of which it sometimes constitutes the greater part, or appears in cavities only; also in beds or masses, which are sometimes extremely large. It is usually accompanied by the compact and ochreous varieties of this species.

Though not very common, it is yet found in large quantities in certain countries, as Saxony, Bohemia, Lancashire in England, &c.

In the *United States*. In *Pennsylvania*, at the Perkiomen lead mine. (*WETHERILL.*)—In *Connecticut*, at Kent, in primitive rocks. (*GIBBS.*)

(*Remarks.*) It is difficult to melt; but yields from about 60 to 80 per cent. of iron of excellent quality, whether cast or forged. The English plate iron and iron wire are prepared chiefly from this iron.—When reduced to powder, it is sometimes employed for polishing other metals.

The term Hematite is derived from the Greek *αἷμα*, *blood*, in allusion to the red color of this mineral.

3. COMPACT RED OXIDE OF IRON.* The color of this variety, like that of the preceding, is most commonly brownish red, often with a mixture of steel gray;—or it is intermediate between dark steel gray and blood red; indeed its surface is often a dark metallic gray with a shining lustre. Its streak and powder are blood red.—Its texture is compact, and its fracture even or conchoidal, sometimes uneven; it is dull, or has only a feeble lustre. Sometimes it possesses a slaty structure.—It is usually a little less hard, than the red hematite, and breaks without difficulty. It is sometimes invested with a coat of the ochreous variety, which soils the fingers.

It occurs in amorphous masses, and sometimes under imitative forms, as globular, reniform, &c.—Sometimes also it presents false crystals, whose forms are pyramidal or cubic, derived from quartz, sulphuret of iron, &c. It seems probable, that the sulphuret of iron is sometimes converted by decomposition into this compact red oxide; for in some of these cubic crystals a portion of sulphuret of iron is found at the centre.—Its specific gravity lies between 3.42 and 4.23.

* Fer oxidé rouge compacté. *Brongniart*. Dichter Rotheisenstein. *Werner*. Hausmann. Compact red ironstone. *Kirwan*. Compact Red Iron ore. *Jameson*. *Aikin*. *Phillips*. La mine de fer rouge compacte. *Bréchant*. Fer oligiste terreux. *Haüy*.

A cubic crystal from Thuringia yielded Bucholz iron 70.5, oxygen 29.5. A specimen, analyzed by Lampadius, yielded oxide of iron 65.4, silex 20.7, alumine 9.3, oxide of manganese 2.7;=98.1.

Its *Geological situation* and *Localities* are similar to those of the red hematite, already mentioned. It is often associated with quartz and hornstone.—In the Fichtelberg, near Bareuth, its beds separate into columns, like basalt.

It the *United States*. In *Missouri*, at the head of Gasconade river. (*SCHOOLCRAFT.*)—In *Tennessee*, on Elk river, very hard and compact. (*SCHOOLCRAFT.*)—In *New York*, at Canton, St. Lawrence County. (*HALL.*)

It passes into the preceding and following varieties of this species, and into some varieties of the argillaceous oxide of iron.

It commonly yields good iron; its forged iron is somewhat soft.

4. OCHREY RED OXIDE OF IRON.* (Red ochre.) Its color is blood red, sometimes lively, and sometimes it is brownish red. It is usually friable, and always easily reduced to powder. Its fracture and general aspect are dull and earthy. It strongly soils the fingers, but is not unctuous, like the scaly variety. Its specific gravity is about 3.00. Seldom in large masses, it usually appears on the surface of other ores of iron, or is disseminated.

It never effervesces with acids, unless from accidental mixture; and is often a very pure oxide. By mixture, however, with argillaceous earths, it gradually passes into reddle, bole, &c.

It almost always accompanies the two preceding varieties, and is often found with specular and sparry iron. In its purest state, it seldom occurs in large quantities.

In the *United States*, this ochre, more or less pure, occurs in numerous instances, and sometimes very abundantly. In *Ohio*, between Wheeling and Zanesville, it occurs in beds of ferruginous sandstone. (*ATWATER.*)

(*Uses and Remarks.*) It melts easily, and furnishes a soft and very good malleable iron.—When purified by agitation in water, it constitutes an important paint for many purposes. It may be made to assume various tints of red, by changing its state of oxidation by the action of a mild heat.—To this variety belongs the pigment, called *Indian red*, brought from the isle of Ormus, in the Persian gulf.

Haüy has arranged this species under specular iron, (Fer oligiste). Indeed the crystals of the latter are sometimes found adhering to the sides of cavities in the former; and some specimens of the red oxide divide into rhombs, slightly acute, resembling the primitive form of specular iron.

* Fer oxidé rouge ocreux. Brongniart. Ochricher Rotheisenstein. Werner. Hausmann. Red ochre. Kirwan. Jameson. Aikin. Phillips. Fer oligiste terreux. Haüy.

The Red oxide of iron is rare in Norway, Sweden, Russia, and Hungary. (*JAMESON.*)

SPECIES 7. BROWN OXIDE OF IRON.

Fer oxidé brun. *Brongniart.* Braunereisenstein. *Werner.* La Mine de fer brune. *Brochant.* Fer oxidé rubigineux. *Haüy.* Brown Iron ore. *Aikin.* *Phillips.*

Hydrate of Iron.

This, like the preceding species, is destitute of a lustre strictly metallic; and its general aspect is stony or earthy. Its prevailing color is brown, usually deep, sometimes blackish brown, and sometimes with a strong tinge of yellow. Its powder, however, is brownish yellow, or yellowish brown. This powder is less fine, and less hard, than that of the red oxide of iron.

It is frequently amorphous, sometimes in an earthy state, and often presents certain imitative forms; indeed, according to Haüy, it is sometimes crystallized in cubes. The texture of its masses is compact or fibrous.

Its specific gravity varies from 3.40 to 4.02. With a weak and delicate needle some specimens discover magnetic polarity; but, in general, it is scarcely sensible, unless by double magnetism.

(*Chemical characters.*) Most of its varieties become reddish or reddish black by calcination. It is infusible by the blowpipe; but, on charcoal, it acquires more or less of polarity. According to Daubuisson, it is essentially composed of oxide of iron 85, water 15, being in fact a *Hydrate of iron*.—It is, however, never pure, but contains more or less of the oxide of manganese, silex, and alumine.—He also includes under the same name the *nodular*, *granular*, and *bog ore* varieties of the following species. (See analyses under the several varieties.)

The color of its powder sufficiently distinguishes it from the preceding species.

*Var. 1. SCALY BROWN OXIDE OF IRON.** Its color is brown, sometimes inclining to steel gray. It is nearly or quite friable; and, though sometimes in small masses, usually occurs in crusts. It presents small scaly particles with a glistening lustre, somewhat metallic. It is unctuous to the touch, and soils the fingers.

It is usually found in cavities of the hematitic variety.

2. HEMATITIC BROWN OXIDE OF IRON.† (Brown hematite.) Its true color is often nearly clove brown; but it varies from blackish or bluish brown to yellowish brown or brownish yellow. Its surface is often

* Brown scaly Iron ore. *Kirwan.* Brauner eisenrahm. *Werner.* Scaly brown Iron ore. *Aikin.* *Phillips.*

† Brauner glaskopf. *Werner.* Brown hematite. *Kirwan.* *Aikin.* Fer oxidé brun fibreux. *Brongniart.* Fer oxidé hématite. *Haüy.* Fasriger Brauneisenstein. *Hausmann.* Fibrous Brown Iron ore. *Jameson.* *Phillips.*

tarnished; hence it is sometimes steel gray, irised, or velvet black; indeed some specimens seem to be covered with a beautiful, shining, black varnish. But its streak and powder are always very nearly brownish yellow. Its external lustre is considerable, sometimes splendid.—It is, in general, perfectly opaque.

Its structure is always fibrous; and the fibres, either straight or curved, are sometimes extremely delicate and close. Though sometimes parallel, they usually diverge, or even radiate from a centre. Its lustre is variable, but commonly glistening, and either silky or resinous.

This variety, seldom amorphous, presents a great number of imitative forms. Thus it occurs reniform, stalactical, dendritic, cylindrical, coralloidal, tuberos, botryoidal, &c. The cylinders are sometimes aggregated in rows. Its masses often present concentric, lamellar concretions.

It is less hard, and more easily broken, than the red hematite; and sometimes presents a conchoidal fracture in one direction.

According to Daubuisson, it contains, on a mean of two analyses, oxide of iron 80.5, water 14.5, oxide of manganese 2.0, silex 2.0; = 99.

(*Geological situation.*) This ore occurs in primitive, transition, and secondary rocks. It exists in veins, beds, or masses, and accompanies the compact variety, in the cavities of which it is often found. It often accompanies sparry iron.

(*Localities.*) It is abundant in Bohemia, Saxony, Nassau, Henneberg, &c.

In the *United States*. In *Arkansas Territory*, 5 miles north from Strawberry river, in Lawrence County, it occurs stalactical, reniform, &c. (*SCHOOLCRAFT.*)—In *Illinois*, Gallatin County, on Peter's creek, 17 miles from Shawneetown, and at the Three Forks of Grand Pierre creek, in considerable quantities. (*JESSUP.*)—In *Virginia*, on the Shenandoah.—In *Maryland*, fine specimens are found 17 miles from Baltimore. (*HARDEN.*)—In *Pennsylvania*, stalactical in a cavern at Messersburgh.—Also at Jenkintown, Montgomery County, stalactical and mammillary, very beautiful. (*CONRAD.*)—Also near Lancaster.—At the Perkiomen lead mine, it is mammillary, and covers crystals of quartz. (*SCHAEFFER.*)—At Upper Dublin, it is often in geodes, the interior of which is botryoidal, mammillary, or stalactical, and black. (*LEA.*)—In *New Jersey*, in the northern parts of Burlington County, mammillary, and ploughed up in the fields. (*WOODBIDGE.*)—In *New York*, on Staten island, in detached, stalactical or mammillary concretions, blackish brown, often with a shining surface. (*PIERCE & TORREY.*)—In *Connecticut*, at Salisbury, associated with the other varieties of the Brown oxide. It is often in stalactites of uncommon beauty, whose exterior presents a strong gloss. It is sometimes invested with a delicate sooty coat, which appears to be oxide of manganese.

The ore is embraced in clay, which forms a bed in the side of a hill of moderate elevation; but the surrounding country is primitive, having mica slate for its basis. This mine has been open about 70 years, and the ore is still very abundant. Also at Kent, where it occurs stalactical, mammillary, &c. It is contained in clay, which forms a bed in gneiss, the only rock in the immediate vicinity. The iron, obtained from this ore, is said to be more brittle, than that from Salisbury. The clay of this bed and that of Salisbury exhibits various colors, and will undoubtedly furnish valuable pigments. (*SILLIMAN.*) The ore from Salisbury supplies the Salisbury and Ancram furnaces, and yields some of the best iron in the United States. (*GIBBS.*)—In *Rhode Island*, at Scituate.—In *Vermont*, at Monkton.—Also at Bennington, where it is associated with earthy oxide of manganese. The ore is covered by a stratum of sand, containing numerous quartz pebbles; and yields on an average about 33 per cent. of iron. (*HALL.*)—In *New Hampshire*, at Chesterfield, on West River mountain, in mica slate;—also at Pembroke.

(*Remarks.*) It is a very fusible ore, and commonly yields from 40 to 60 per cent. of iron. Its cast iron is ordinarily inferior to that obtained from the red oxide of iron. Its forged iron is hard, very malleable, and furnishes excellent steel. Indeed the Brown Hematite may be converted into steel at about the same expense, as into bar iron. In this way much of the German steel is manufactured.

3. COMPACT BROWN OXIDE OF IRON.* Its color is, in general, nearly clove brown, either light or dark, sometimes passing to blackish brown, and sometimes the brown is mixed with yellow or even steel gray. Its surface is sometimes reddish; but its streak and powder are yellowish brown, sometimes passing to ochre yellow.

Its texture is compact, and never fibrous, like the preceding variety. According to Brongniart, its structure is sometimes slaty.—Its fracture is commonly even, sometimes a little conchoidal, and also passes to uneven or earthy. It is dull, or has only a glimmering lustre.

Though usually in amorphous masses, it sometimes assumes certain imitative forms, as reniform, botryoidal, cylindrical, cellular, stalactical, &c.—It is sometimes pseudomorphous, presenting itself in cubes, or dodecaedrons with pentagonal faces, derived from pyrites.

It is usually less hard, than the brown hematite; and its specific gravity is between 3.4 and 3.7.

A mean of three analyses by Daubuisson gives oxide of iron 82.0, water 11.3, oxide of manganese 0.3, silex 2.6;=96.2. The proportion of manganese is in some specimens considerably greater; indeed this ore sometimes passes by insensible shades into the oxide of manganese.

* Fer oxidé brun compacte. *Brongniart.* Dichter braun eisenstein. *Werner.* Compact brown ironstone. *Kirwan.* Compact Brown Iron ore. *Jameson.* Aikin. *Phillips.* Gemeiner Brauneisenstein. *Hausmann.*

Its *Geological characters* and *Localities* are, in general, the same as those of the preceding variety, with which it is usually connected. It is, however, much more abundant; and is found in veins, beds, and masses, which are often very large. It sometimes forms the substance of certain fossils, such as madreporites, &c.

Both the compact and hematitic varieties are very often accompanied by the ochrey brown oxide of iron.

In the *United States*; in *Maryland*, on the Blue Ridge, at Mount Alto, Hughe's mine, it occurs in stalagmites, or very beautifully dendritic, resembling, in large masses, a grove of trees. (*HARDEN*.)—In *Massachusetts*, at Dalton, incrusting rocks.

This variety is much explored; and yields about 50 per cent. of good bar iron.

4. OCHREY BROWN OXIDE OF IRON.* (Yellow ochre.) Its color is yellowish brown of different shades, sometimes inclining to ochre yellow, and sometimes to brown. It occurs in dull, earthy masses, which are nearly or quite friable, and strongly soil the fingers.

It contains oxide of iron 83, water 12, silex 5. (*DAUBUISSON*.)—Though it sometimes reddens when slightly heated, it never assumes a lively red, like yellow earth, from which it is hereby distinguished.

It usually accompanies the two preceding varieties, and is often found with sparry iron.

In the *United States*; in *Vermont*, at Pittsford, it occurs in beds and veins in limestone. It is explored, and yields about 25 per cent. of iron. (*HALL*.)

The preceding species, which is abundant in Germany, France, &c. is, according to Werner, rare in Norway, Sweden, and Russia.

SPECIES 8. ARGILLACEOUS OXIDE OF IRON.

In this species, the oxide of iron is united, either by mixture or combination, with several other substances, but principally with clay, which is composed of silex and alumine. Its varieties are so numerous, that it is impracticable to give any general characters, which will be useful.

Var. 1. COLUMNAR ARGILLACEOUS OXIDE OF IRON.† This variety occurs in masses, composed of little prisms or columns, either straight or curved, often long and slender, and aggregated almost always parallel to each other; sometimes, however, they diverge. They separate easily; and are sometimes articulated, like basalt.

* Fer oxidé brun ocreux. *Brongniart*. Ochricher Brauneisenstein. *Werner*. *Hausmann*. Ochrey Brown Iron ore. *Jameson*. *Aikin*. *Phillips*.

† Stanglicher thoneisenstein. *Werner*. Columnar Red Clay Iron ore. *Jameson*. Fer oligiste bacillaire—conjoint. *Haüy*. Columnar Clay ironstone. *Aikin*. *Phillips*. Stanglicher rother thoneisenstein. *Hausmann*.

It is very brittle, and presents a dull, fine grained, earthy fracture. It adheres to the lip.

Its color varies from cherry red to a deep brownish or even blackish red, sometimes with a tinge of yellow. Its streak and powder are also red. Its specific gravity is between 3.4 and 4.0; and it is sometimes magnetic, especially by double magnetism.

A specimen yielded Brocchi oxide of iron 50.0, water 13.0, silex 30.5, alumine 7.0;=100.5.

It occurs in secondary rocks, particularly in stratified argillaceous beds. It is frequently in the vicinity of earths, exposed to subterraneous fires, to the action of which its structure has been attributed. But it also occurs in situations, where such fires do not appear to have existed, as in the island of Arran, &c.—It occurs in Bohemia and other parts of Germany.—In England, near Wednesbury, its columns are coated with pyrites in the interior of small, lenticular masses. (*PHILLIPS.*)

In the *United States*. In *New Jersey*, at the Navesink Hills.—In *New York*, on Long island, near Plandome, in small columns. (*MITCHILL.*)—In *Massachusetts*, at Gayhead, in Martha's Vineyard.

It is a rare variety, but is sometimes explored.

2. GRANULAR ARGILLACEOUS OXIDE OF IRON.* This variety occurs in small masses or grains, nearly or quite spherical, and often equal in size to a pea, or still larger. These globules are composed of thin, concentric layers, which decrease in density as they approach the centre. The exterior layers are compact, and present an even, glistening fracture with a resinous lustre, whereas the centre of the grain is almost always friable, and has a dull, earthy fracture. They are easily broken, and may be cut by a knife. Their specific gravity is between 3.14 and 3.40.

Their true color is yellowish brown, light or dark, and sometimes even blackish brown; their streak also is usually yellowish brown; but the color of the surface is often altered by the earth, which unites them.

It is composed, according to a mean of two analyses by Daubuisson, of oxide of iron 71.5, water 14.5, oxide of manganese 0.5, silex 7.5, alumine 3.5;=97.5. Another analysis by Mollinghof gives oxide of iron 60, water 15, alumine 13, silex 12.—According to these analyses, this variety evidently belongs to the brown oxide, or hydrate of iron.

These grains, sometimes solitary, are generally united by a ferruginous cement, either argillaceous or calcareous, which adheres to their surface.

(*Geological situation and Localities.*) This variety is found in secondary rocks; and exists in beds, or in masses, deposited in fissures

* Böhnerz. *Werner*. Pea ore. *Jameson*. Pisiform or granular iron stone. *Kirwan*. Fer oxidé rubigineux globuliforme. *Haüy*. Fer oxidé brun granuleux. *Brongniart*. Hydrate of Iron. *Daubuisson*. Pisiform Clay ironstone. *Alkin*. *Phillips*. Korniger gelber thoneisenstein. *Hausmann*.

or hollows. Hence it is often found in calcareous rocks, which are so frequently traversed by fissures, or contain cavities. It is sometimes embraced in beds of clay, lying over compact limestone; and sometimes its beds are immediately under the soil.—It has been remarked, that the grains of the same locality are nearly of equal size.

Sometimes it contains fossil shells, penetrated by the oxide of iron.

This ore is abundant in some countries, particularly in France, Switzerland, and some parts of Germany.

In the *United States*. In *New Jersey*, in the southern part of the State, in a ferruginous clay. (*WOODBRIDGE*.)—At the southern part of Pompton plain, it is explored, and mixed with harder oxides of iron. (*PIERCE*.)—In *New York*, near Rome, associated with secondary limestone. (*GIBBS*.)—Also on Staten island, where it sometimes forms extensive beds. (*PIERCE*.)—In *Connecticut*, at Salisbury.

(*Remarks*.) This ore is easily explored and worked, and sometimes yields from 30 to 40 per cent. But it is obvious, that the result must depend much on the quantity of cement. The iron, which it yields, is sometimes very brittle, in consequence probably of containing the phosphate or phosphuret of iron; the phosphorus being derived from the animals, whose remains appear in this ore.

3. LENTICULAR ARGILLACEOUS OXIDE OF IRON.* This variety differs but little from the preceding. Its masses are composed of very minute distinct concretions, sometimes round or granular, but more frequently lenticular or flattened. It is easily broken; and its fracture has a moderate lustre, somewhat metallic.—Its colors are brownish red, yellowish or blackish brown, and sometimes steel gray. The color of its streak varies but little from that of the mass. Its specific gravity is between 3.0 and 3.8.

A specimen from Radnitz yielded Lampadius oxide of iron 64.0, water 5.0, alumine 23.0, silex 7.5;=99.5. In a specimen from Daubs, Daubuisson found peroxide of iron 73, water 14, silex 9, oxide of manganese 1;=97.

It occurs in masses or beds in amygdaloid, sandstone, shell limestone, and in alluvial deposite.—Fossil shells are not uncommon in this ore.

In the *United States*; in *New York*, Ontario County, at Ontario, Williamson, &c. it occurs in insulated masses or extended beds, in alluvial deposite. It often contains very perfect fossil shells; and yields about 30 per cent. of iron. (*M'NAB. EATON*.)

It ordinarily melts with ease, affording from 30 to even 60 per cent. of good iron.

* Linsenformiger thoneisenstein. *Werner*. Lenticular Red Clay Iron ore. *Jameson*. Fer oxidé brun granuleux. *Brongniart*. Lenticular Clay ironstone. *Aikin*. *Phillips*.

4. NODULAR ARGILLACEOUS OXIDE OF IRON.* This remarkable variety occurs in masses, varying from the size of a walnut to that of a man's head. Their form is spherical, oval, or nearly reniform, or sometimes like a parallelopiped with rounded edges and angles. They have a rough surface, and are essentially composed of concentric layers.

These nodules often embrace at the centre a kernel or nucleus, sometimes moveable, and always differing from the exterior in color, density, and fracture. In this case, the color near the exterior is ordinarily brown or dark yellowish brown; but within, it becomes paler or more yellow, and at the centre is sometimes ochre yellow.—The texture of the exterior is compact and solid; but the density gradually diminishes to the centre, which has an earthy texture. Sometimes there is a cavity at the centre, either empty, or partly filled with sand, or a friable, yellow earth, which is moveable.—The fracture toward the surface is even, or nearly conchoidal, and sometimes glistening; but near the centre it is dull, and earthy.

Its specific gravity is about 2.57; and its hardest parts are sometimes difficultly scraped by a knife.

According to a mean of two analyses by Daubuisson, it is composed of oxide of iron 77.0, water 13.5, oxide of manganese 1.0, silex 6.0, alumine 0.5;=98. Like the brown oxide, it is a hydrate of iron.

(*Geological situation and Localities.*) This ore occurs in beds of ferruginous clay in secondary rocks, and sometimes in alluvial deposits of clay, loam, or sand. In France, it has been found in banks of sand, which cover beds of yellow earth, or even in the interior of these beds. (*SAGE.*) It occurs also in England, Scotland, Germany, &c.

In the *United States*. In *Maryland*, it forms extensive beds 3 miles S. and W. from Baltimore. The nodules are composed of concentric layers, between which very beautiful, dark brown, lenticular crystals of sparry iron are sometimes found. These crystals are very minute, occur in druses, and give to the surface the rich aspect of velvet. (*GILMOR. SILLIMAN.*) These nodules are by some referred to the common variety of Argillaceous oxide of iron.—Also at Bomb Shell hill, near Bladensburg, in nodules, which are sometimes perfectly globular, and vary from 2 to 8 inches in diameter. When broken, the crust has a metallic aspect; and the interior, sometimes filled with oxide of iron, more frequently contains a fine sand. When exposed to a strong heat, these nodules burst with explosion. (*HARDEN.*)—In *Massachusetts*, near Plymouth.

(*Remarks.*) This ore is frequently worked, and yields very good iron.—To the hollow nodules containing a moveable nucleus, the

* Nodular Iron ore. *Kirwan*. Eisenniere. *Werner*. Reniform Brown Clay Iron ore. *Jameson*. Fer oxidé geodique. *Hauy*. Fer oxidé brun Étite. *Brongniart*. Hydrate of iron. *Daubuisson*. Variety of Clay ironstone. *Aikin*. *Phillips*.

ancients gave the name of *Eagle stone*, from an opinion that this bird transported them to its nest to facilitate the laying of its eggs.—Nothing very satisfactory can be said on the manner, in which these nodules have been formed.

Those spheroidal masses, composed of concentric layers, alternately brown and compact, yellow and friable, which are sometimes found in ferruginous marl, may be referred to this variety.

5. COMMON ARGILLACEOUS OXIDE OF IRON.* Its more common colors are gray, yellowish, bluish or reddish gray, brown, yellowish or reddish brown, and sometimes brick red. By exposure to the air its paler colors often become darker.

It has usually an earthy aspect, but is sometimes considerably compact, or has a slaty structure. Its fracture is dull, earthy or uneven, and sometimes even, or a little conchoidal.—It is, in general, easily cut by a knife, or broken, but is sometimes considerably hard. It usually adheres somewhat to the tongue, and, when moistened, often yields an argillaceous odor. Its specific gravity varies from 2.93 to 3.47.

It occurs in amorphous or tabular masses, and sometimes in nodules.

Before the blowpipe it blackens, but does not melt. In a specimen from Bohemia, Lampadius found oxide of iron 39, water 9, alumine 40, magnesia 6, silex 5, sulphur 1.—Some specimens, referred to this variety, have been found to contain carbonic acid.

It sometimes resembles compact limestone or indurated clay, but has a greater specific gravity.

(*Geological situation and Localities.*) This ore occurs in beds, veins, or in insulated masses, or in nodules considerably large in argillite, shale, bituminous shale, sandstone, &c. Hence it is often in the vicinity of coal mines. It sometimes presents vegetable impressions; and sometimes forms the substance of organic remains.

Sometimes its masses are traversed by interstices, filled with carbonate of lime, carbonate of iron, &c. thus forming a variety of *Septaria*. (See *Septaria* under *Marl*.)

The *Fer oxidé cloisonné* of Haüy, which presents flattened spheroidal masses, divided into prisms, or into polygonal cells by partitions, may be referred to this variety.

This ore is abundant in England and Scotland, particularly in the vicinity of coal mines.

In the *United States*, it occurs in a number of places, in some of which it is worked. In *Maryland*, on the west side and at the foot of the South Mountain, extending from the Potowmac into *Pennsylvania*. It is usually imbedded in a ferruginous clay;—also in Harford

* Gemeiner thoneisenstein. *Werner*. Common Brown Clay Iron ore. *Jameson*. Common argillaceous Iron ore. *Kirwan*. Fer terreux argileux commun. *Brongniart*. Clay ironstone. *Aikin*. *Phillips*.

County. (*HARDEN.*)—In *Pennsylvania*, it is worked in the Counties of Fayette, Alleghany, &c.—In *Ohio*, in several parts of the State.

This variety yields from 30 to 40 per cent. of iron. It sometimes passes into the compact brown oxide of iron.

JASPERY ARGILLACEOUS OXIDE OF IRON.* This subvariety is brownish red, reddish or yellowish brown, and has the external aspect of *Jasper*. It is opaque, and has a flatly conchoidal or an even fracture, with a feeble lustre. It yields to the knife with some difficulty. Its specific gravity is 3.19.

In Austria, at Fischau, it is associated with secondary rocks.—In England, it occurs at Billingsly;—and in Cornwall, it is connected with jasper. (*PHILLIPS.*)

6. BOG ORE.† This ore presents considerable diversity of texture, fracture, and color in the same bed, or even in the same specimen. It sometimes resembles the ochreous and compact brown oxides of iron, and might, in some instances, be mistaken for a scoria.

Its prevailing colors are yellowish brown, light or dark, brownish yellow, brown, blackish or reddish brown.

It occurs in amorphous, rounded, or tuberos masses, which are very seldom compact and homogeneous, being almost always corroded, porous, or cellular. It appears also in crusts or grains.

Sometimes it is nearly or quite friable, soils the fingers, and has a dull, earthy, or uneven fracture.—Sometimes it is more compact and solid, but still easily broken, and its fracture becomes nearly even, or flatly conchoidal with a resinous lustre more or less shining.—Sometimes indeed the same specimen presents a number of compact, undulated zones with a shining fracture, while the intermediate portions are friable and ochreous. Its specific gravity is variable, sometimes 2.94.

According to Daubuisson, it is composed of oxide of iron 61, water 19, oxide of manganese 7, silex 6, alumine 2, phosphoric acid 2.5; =97.5. Sometimes also chromic acid, magnesia, or lime is present. The phosphoric acid is derived from vegetables.

(*Geological remarks.*) Bog ore is found, often abundantly, in low places in alluvial deposits, or in marshy or swampy grounds, or even under water, as on the bottom of ponds. When in meadows or other low grounds, it often lies immediately under the soil, but sometimes alternates with beds of clay or sandstone.—The interior of its cells is sometimes lined with a blue phosphate of iron. It often embraces the remains of vegetables, or shells.

* Jaspisartiger thoneisenstein. *Werner*. Jaspery Red Clay Iron ore. *Jameson*.

† Rasen eisenstein. *Werner*. Bog Iron ore. *Jameson*. *Aikin*. *Phillips*. Lowland Iron ore. *Kirwan*. Fer terreux limoneux. *Brongniart*. Hydrate of iron. *Daubuisson*. Limonit. *Hausmann*.

This ore is of recent, and even daily formation, being deposited from stagnant water, containing the oxide of iron.—Roots of trees and even shells are sometimes converted into this ore.

Bog ore is sometimes distinguished into three varieties, according to its geological situation. Thus, according to Werner, the first or *lowest* deposit is earthy, friable, and yellowish, and is called *morassy* ore.—As the water gradually evaporates, the deposits become browner, more indurated, and constitute *swampy* ore.—When the waters are nearly or quite evaporated, and soil appears, the swampy ore becomes harder, darker colored, and is called *meadow* ore.

Bog ore is said to be less frequent in the south than in the north of Europe, where it is abundant in the vicinity of the Baltic, &c.

In the *United States*, this ore is very common, either in alluvial earths, or at the bottom of ponds and lakes. In the southwestern parts of *New Jersey*, its several varieties are abundant. The same place may often be explored a *second* time in 20 years, or even less, in consequence of the renewal of this ore by deposition from water. Roots of trees and shells are here sometimes converted into bog ore. In the furnace, it is often mixed with other kinds of ore, brought down the Delaware from Easton. (*CONRAD. WOODBRIDGE.*)—In *New York*, on the island of New York, in large beds; it is reddish brown, cellular, and contains much oxide of manganese. (*PIERCE & TORREY.*)—In *Vermont*, at the north end of Lake Champlain. This ore is worked at the furnaces in Vergennes, where the brown hematite from Monkton, and the magnetic iron from the west side of the lake are also used. (*GIBBS.*)—In *Massachusetts*, Plymouth County, in Carver and Middleborough, it is abundant at the bottom of ponds, from which it is dragged. (*GIBBS.*)—Also at Groton, where it occurs earthy, or with a resinous fracture, and yields hot short iron. (*J. F. DANA.*)

(*Remarks.*) This ore generally yields about 30 or 35 per cent. of cast iron, which is rendered somewhat brittle by containing phosphate of iron; hence also its bar iron is often more or less *cold short*, and cannot be employed for plate iron or for wire. It is advantageously melted with the brown oxide and other ores of iron. The hardest varieties of bog ore are the least fusible.

Oxide of iron, deposited in loose earth or sand, often exerts a very strong cementing power. Hence roots of trees, which penetrate banks of sand, have sometimes a kind of tube or case formed around them. Hence also particles of sand are sometimes firmly united into masses.

APPENDIX TO ARGILLACEOUS OXIDE OF IRON.

The following minerals, concerning most of which but little is known, may for the present be placed in this appendix.

1. PITCHY IRON ORE. *PHILLIPS.*

Eisen Sinter. *Werner.* Eisen Pecherz. *Karsten.* Fer oxidé resinite. *Haüy.* Iron Sinter. *Jameson.*
Pitchy Bog Iron ore. *Aikin.* Pittizit. *Hausmann.*

It occurs in crusts, and is sometimes reniform or stalactitic, or in masses composed of lamellar concretions. Its fracture is imperfectly conchoidal or uneven, with a resinous lustre more or less shining. It is translucent, at least on the edges; and its colors are grayish black, blackish or yellowish brown, or brownish yellow. Its powder is nearly lemon yellow. It yields to the knife; and its specific gravity is about 2.35.

When slowly heated in the flame of a candle, it melts, and becomes magnetic. It yielded Klaproth oxide of iron 67, water 25, sulphuric acid 8.

It has been found in the mines of Saxony, and Silesia.

2. VITREOUS BLACK OXIDE OF IRON.

Fer oxidé noir vitreux. *Haüy.*

It slightly scratches glass; and has a yellow powder. Its specific gravity is 3.2.

In the flame of a candle, it becomes magnetic, but does not melt. It contains oxide of iron 80.25, water 15.0, silex 3.75;=99. (*VAUQUELIN.*)

In France, department of Bas-Rhin, it forms a crust on brown oxide of iron.

3. STILPNOSIDERITE. *JAMESON.*

It is opaque; and its color is blackish brown or nearly black. Its powder is yellowish brown. It occurs amorphous, reniform, or dendritic, and its masses are often composed of curved lamellar concretions. Its fracture is conchoidal with a resinous lustre, sometimes highly shining. Its specific gravity is 3.77.

It contains, according to Ullmann, oxide of iron 80.5, water 16.0, silex 2.25.

In Saxony and Bavaria, it is associated with brown oxide of iron.

Its name is from the Greek *σιλπνος*, *shining*, and *σιδηρος*, *iron*.

4. BLUE IRONSTONE. *JAMESON.*

Blaueisenstein. *Klaproth.*

Its color is indigo or lavender blue. It occurs in opaque masses, which yield to the knife, and have a dull, uneven fracture. Its specific gravity is 3.20.

It loses its color before the blowpipe; and contains oxide of iron 40.5, water 3.0, silex 50.0, soda 6.0, lime 1.5.

It is found in Southern Africa, on Orange river; and is employed as a pigment at the Cape of Good Hope.

5. HEDENBERGITE. *BERZELIUS. THOMSON.*

It occurs in masses, composed of shining plates, which break into rhombic fragments. It scratches the carbonate but not the fluat of lime. Its color is greenish black, or brown, and that of its powder pale brownish green. Its specific gravity is 3.1. It phosphoresces both by heat and friction.

Before the blowpipe, it becomes dull and magnetic. It contains, according to *Hedenberg*, silex 40.6, oxide of iron 35.2, water 16.1, lime 3.4, alumine 0.4, oxide of manganese 0.7, carbonic acid 1.6;=98.

It is found at Tunaberg, in Sweden, forming thin layers in calcareous spar, and associated with sulphuret of iron, quartz, and mica.

SPECIES 9. CARBONATE OF IRON.

Fer oxidé carbonaté. *Haüy.* Spath eisenstein. *Werner.* Sparry Iron. *Jameson.* Sparry Iron ore. *Kirwan. Aikin.* Fer spathique. *Brongniart. Brochant.* Eisenspath. *Hausmann.* Spathose Iron. *Phillips.*

Sparry Iron.

Its colors vary from grayish white or yellowish gray to pale yellow or yellowish brown, and thence pass to brown, reddish brown, or even brownish black. When recently obtained from the mine, it is usually grayish or yellowish gray; but, by exposure to the air, assumes the darker colors just mentioned. This change is produced by the combination of oxygen with the iron, or more frequently with the manganese, which this ore so often contains.—The lighter colored varieties are translucent, at least at the edges, and the crystals sometimes transparent; but the darker colors are often opaque.

Its structure and fracture are almost always foliated; and the folia, either straight or curved, have a pearly lustre, sometimes shining, and sometimes very feeble. It is harder than calcareous spar; and its specific gravity lies between 3.64 and 4.00. It is easily frangible, falling into rhomboidal fragments.

Carbonate of iron is susceptible of mechanical division in three directions, parallel to the sides of an obtuse rhomb, which is its primitive form. This rhomb, according to *Haüy*, is perfectly similar to the primitive form of carbonate of lime; but, according to *Wollaston*, its angles are 107° and 73° . The secondary forms of this mineral resemble those of carbonate of lime.

It sometimes presents the primitive rhomb, either entire, or truncated on its summits or edges—and sometimes a more obtuse rhomb.—But one of its most common forms is *lenticular*, originating from the last mentioned rhomb, whose obtuse edges are rounded; these crystals often adhere by their acute edges to other minerals, and are sometimes extremely minute, occurring in druses.

The very small rhombs are sometimes so closely aggregated, that the texture of the mass appears scaly;—and sometimes they resemble thin plates with their edges bent back, like those of a hat.

Sparry iron often occurs in *laminated* and *lamellar* masses. Sometimes the laminæ are very large; and sometimes so small, that the mass resembles certain varieties of granular limestone. Some specimens resemble brown blende.

It has also been observed with a fibrous structure;—and in tabular masses, striated perpendicularly to the broader surfaces.

Sometimes also its texture is nearly or quite *compact*, and the fracture a little splintery;—or it occurs in porous masses.

Another variety has a stony aspect, a bluish or brownish gray color, an earthy or a flatly conchoidal fracture, and a specific gravity below 3.40.

According to the experiments of Richter and Descotils, some ores, usually referred to the argillaceous oxide of iron, are in fact an argillaceous carbonate of iron.

It has also been observed in globular masses, like the oolite.

In fine, some ores of iron are merely sandstone, impregnated with carbonate of iron.

(*Chemical characters.*) Before the blowpipe it blackens, and acquires the power of moving the magnetic needle, but does not melt. In nitric acid it becomes brown, and slowly dissolves with a moderate effervescence.—This ore appears to be essentially composed of iron slightly oxidated and carbonic acid; but it usually contains variable quantities of the oxide of manganese, lime, and magnesia. Those varieties, which contain a large quantity of magnesia, are so refractory in the fire, that the iron can scarcely be reduced; they however become more fusible by long exposure to the atmosphere.

A specimen, analyzed by Bayen, yielded oxide of iron 66, carbonic acid 34. From a crystal, Bucholz obtained iron slightly oxidated 59.5, carbonic acid 36.0, water 2.0, lime 2.5. In the laminated variety Descotils found iron slightly oxidated 49.0, carbonic acid 37.5, oxide of manganese 1.5, magnesia 12.5, lime 0.3;=100.8. Another specimen yielded Klaproth oxide of iron 58.0, carbonic acid 35.0, oxide of manganese 4.25, magnesia 0.75, lime 0.5;=98.5.

Not only are its colors darkened, but its specific gravity, and hardness are diminished, and its structure rendered less lamellar by long exposure to the atmosphere.

This ore seems to pass by insensible shades into brown spar, a subspecies of carbonate of lime. Its greater specific gravity and its power of becoming magnetic by exposure to heat will, however, generally serve to distinguish it from brown spar.

(*Geological situation.*) This ore is found both in primitive and secondary rocks. It occurs in metallic veins and beds, and sometimes itself forms very large veins or beds.—It is sometimes associated with the red and brown oxides of iron, the sulphurets of lead and iron, pyritous and gray copper, calcareous spar, brown spar, quartz, &c.

(*Localities.*) This ore occurs in small quantities in Great Britain and Sweden, but is abundant in some parts of Germany, France, and Spain. Fine crystals are found at Traversella in Piedmont.

In the *United States*. In *Maryland*, near Baltimore, in lenticular crystals, attached to gneiss. (*HARDEN.*)—Also in very beautiful, minute, lenticular crystals of a dark brown color, in druses, between layers of nodular, argillaceous oxide of iron, near the same city.—In *Connecticut*, Litchfield County, at New Milford, in gneiss, whose structure is very perfect. The ore is abundant in a gangue of quartz. Its colors vary from yellowish white through brown to almost black, the darker colors belonging to the surface most exposed to the atmosphere. Its specific gravity is 4.00. It is sometimes in very obtuse rhombs; but more frequently in foliated masses. It is strongly magnetic after being heated red hot on charcoal. This appears to be the only locality in the United States, in which Carbonate of iron occurs in quantity. (*SILLIMAN.*)

(*Remarks.*) Sparry iron is a very valuable ore, more especially as it is readily converted into steel; and is hence sometimes called *steel ore*.

M. Haüy mentions a rhombic crystal, in part composed of white carbonate of lime, producing a lively effervescence in acids, and in part of sparry iron, capable of becoming magnetic by heat;—also a specimen of sparry iron in a state of decomposition, and containing in its interior laminæ of carbonate of lime.

Different opinions have been expressed in regard to the origin and nature of this ore, but our limits will not permit an examination of these opinions.

SPECIES 10. SULPHATE OF IRON.

Fer sulfaté. *Haüy. Brongniart.* Eisen vitriol. *Werner. Hausmann.* Rhomboidal vitriol. *Jameson.*
Green vitriol. *Aikin.*

Copperas.

This salt may be recognised by its peculiar, astringent taste. It very rarely occurs in crystals of a determinate form, or in masses of any considerable size. It usually appears in efflorescences, or in tuberos, reniform, or stalactical concretions, or in crusts, composed of fibres or capillary crystals, or in a state of powder. Its colors are commonly some variety of white, gray, green, or yellow, as greenish or yellowish white, &c.

When artificially crystallized, its color is a lively green. Its primitive form is an acute rhomb, which is liable to truncation on its angles and edges. (Pl. V, fig. 14.)

(*Chemical characters.* Its solution in water gives a blue precipitate with the prussiate of potash and iron, by which it is distinguished from alum. It is decomposed, and its iron precipitated by astringent vegetables. Hence the addition of tincture of galls gives a *black* precipitate of gallate of iron, the basis of ink. Hence also a drop of its solution, placed on oak bark, immediately produces a black spot. When pure, it is composed of oxide of iron 25.7, sulphuric acid 28.9, water 45.4. (*BERZELIUS.*)

Sulphate of iron is usually found with sulphuret of iron, by the decomposition of which it is produced. (See sulphuret of iron.) It often effloresces on argillaceous or micaceous slate, which contains the sulphuret of iron or pyrites. Its crystals sometimes appear in the caverns or galleries of mines.

(*Localities.*) This native Sulphate usually occurs in very small quantities, but is not uncommon. In the *United States*, it occurs in considerable quantities in *Tennessee*, Warren County.—In *Maine*, near East Andover, &c. its efflorescences are sufficiently abundant to be worth collection.

(*Uses.*) Its uses in the arts are important, particularly in dying black cloths, and making ink. In medicine it is employed as a tonic.—The *Copperas* of commerce sometimes contains sulphate of copper, and sometimes alum. (See uses of sulphuret of iron.)

SPECIES 11. PHOSPHATE OF IRON. PHILLIPS.

Fer phosphaté. *Haüy. Brongniart.* Prismatic Blue Iron. *Jameson.* Blue Iron ore. *Aikin.* Eisenblau. *Hausmann.*

Its color is usually indigo blue, either deep or pale, but sometimes bluish green, green, or bluish gray. Some varieties are gray by reflected light, and blue, when the light is transmitted. It occurs in regular crystals, and in laminated masses; but more frequently in amorphous masses, more or less indurated, with an earthy texture, or in friable crusts, or in the state of a powder.

It is soluble in diluted nitric acid, but does not communicate its blue color to the solution. To ammonia it does not impart its color, and thus differs from the ores of copper.

*Var. 1. CRYSTALLIZED PHOSPHATE OF IRON.** This variety occurs in crystals, and in laminated masses. It sometimes presents an oblique four-sided prism, whose bases are parallelograms with oblique angles.

* Fer phosphaté cristallisé. *Haüy.* Fer phosphaté laminaire. *Brongniart.* Foliated Blue Iron. *Jameson.* Blattriches Eisenblau, *Hausmann.*

This, which is considered its primitive form, is subject to truncations on its edges and angles. It also presents a six, eight, or twelve-sided prism, with summits having two or more faces. The crystals are often very small, and aggregated into groups, or small masses, which, when broken, exhibit a *fibrous* structure; the fibres appear diverging or confusedly grouped. Sometimes the crystals are rounded or lenticular. —They have a foliated structure in the direction of the axis; and the laminae have a shining lustre, somewhat pearly.

It scratches sulphate of lime, but is scratched by the fluuate of lime; and its powder is pale blue. It is more or less translucent, or even transparent in thin plates. Its specific gravity is between 2.6 and 3.0. It moves the needle by double magnetism.

It also occurs in small, laminated masses, which are sometimes composed of shining, brittle plates, slightly adhering to each other. These plates, separately examined, transmit a greenish light, while, in the mass, they appear deep blue, sometimes, however, in consequence of an earthy phosphate of iron interposed between them.

Before the blowpipe it becomes yellowish, and melts into a globule, which has a metallic lustre. This globule, according to Pansner, crystallizes, while cooling. A specimen from the isle of France yielded Fourcroy and Laugier oxide of iron 41.25, phosphoric acid 19.25, water 31.25, alumine 5.0, silex 1.25; = 98. Another from Alleyras in France yielded Berthier oxide of iron 43.0, phosphoric acid 23.1, water 34.4, oxide of manganese 0.3; = 100.8. Cadet found oxide of iron 41.1, phosphoric acid 36.9, water 13.1, the remainder being lime, alumine, and silex.

(*Localities.*) In the isle of France, it occurs in clay.—In Siberia, and at Luxueil in France, it also occurs in clay, containing oxide of iron, and fossil remains of animals and vegetables;—also in the department of Allier in France.—At Bodenmais, in Bavaria, it is associated with sulphuret of iron in gneiss.—In England, it occurs at St. Agnes in Cornwall, in green prisms, associated with the magnetic sulphuret and carbonate of iron;—and in Derbyshire, in decomposed shale.—In Norway, at Stavern, it occurs in fibrous masses, in sienite, and is sometimes intimately connected with hornblende.

In the *United States*. In *New Jersey*, it occurs in druses of green, lenticular crystals in bog iron ore, and is usually accompanied by the earthy variety. These crystals, which possess the softness and transparency of selenite, become *blue* by exposure to the air, or a moderate heat. (WOODBRIDGE.) On Crosswick's creek, near Allentown, it is sometimes in folia, radiating in small masses, externally blue, but within greenish, soft like talc, and semitransparent. (PIERCE & TORREY.)

2. EARTHY PHOSPHATE OF IRON.* *PHILLIPS*. The *original* color of this variety is generally grayish, yellowish, or greenish white, or with a very slight tinge of blue; but, by exposure to the air, it absorbs oxygen, and becomes indigo blue of different shades, sometimes pale.—It is sometimes in small masses, considerably compact and solid, with a dull earthy fracture, but more frequently it is friable, or even loose, and soils the fingers. It is often a mere coat.

Before the blowpipe it becomes reddish brown, and then melts into a magnetic, blackish globule. In oil it usually acquires a shade of brown. A specimen yielded Klaproth iron slightly oxidated 47.5, phosphoric acid 32.0, water 20.0;=99.5. Vogel obtained oxide of iron 41.0, phosphoric acid 26.4, water 31.0;=98.4. A specimen from New Jersey yielded Vanuxem protoxide of iron 44.53, phosphoric acid 25.85, water 28.27, phosphate of lime 0.40;=99.05. In another specimen, said to have been found in Missouri, the same chemist found protoxide of iron 30.24, phosphoric acid 17.20, water 28.26, clay 13.80, oxide of manganese 5.78, of copper 2.92, lime 0.20;=98.40. The proportion of acid appears to be extremely variable in different specimens.

(*Geological situation and Localities.*) This variety of Phosphate of iron is found in alluvial deposits, where it exists in little nests, or in nodules of various sizes, or in thin crusts, or disseminated in a state of powder. It is thus found in bog iron ore; also in beds of clay, which contain, or at least once contained, *organic bodies*; indeed it frequently appears in cavities formerly occupied by these bodies, and sometimes invests fragments of *bones* or vegetables, contained in the clay.—It also occurs in the mud of rivers, and in peat.

The preceding remarks render it satisfactorily evident, that the phosphoric acid of this mineral has proceeded from organized bodies; and hence the variable proportions, in which it exists.

At the Straits of Taman, between the Black Sea and the sea of Azoph, Phosphate of iron is associated with fossil remains of animals, which have furnished the acid. (Prof. *CLARKE*.)

Fossil bones, &c. are sometimes penetrated by this substance, or it even forms the substance of certain organic remains.

In the isle of Man, at Ballaugh, it occurs in peat, and has been observed in the interior of a fossil elk horn. (*MURRAY*.)—In England, near Liverpool, it is attached to vegetable fibres, disseminated in clay; by exposure, it passes gradually from a dusky blue to a deep indigo blue.

* Fer phosphaté terreux. *Haüy*. Fer phosphaté azuré. *Brongniart*. Blaue Eisenerde. *Werner*. Earthy blue Iron. *Jameson*. Le Fer terreux bleu. *Brochant*. Blue martial earth. *Kirwan*. Erdiges Eisenblau, *Hausmann*. Earthy blue Iron ore, *Aikin*.

In the *United States*. In *New Jersey*, it occurs at Allentown, Monmouth County, and various other parts of the State. It generally accompanies bog ore, or certain argillaceous deposits. It is sometimes in masses, weighing 30 pounds or more, with a texture more or less compact and solid. When first obtained, it is yellowish white; but, by exposure to the air, it assumes a fine blue color. In some instances it appears to contain very little acid. (*CUTBUSH. CONRAD.*) Bones and other organic remains are sometimes penetrated by it; and, according to Say, it sometimes forms the substance of belemnites.—In *Massachusetts*, near Plymouth.—Also at Hopkinton in large quantities, and is employed as a pigment. (*J. F. DANA.*)—In *Maine*, at York, in a ferruginous clay.

It is sometimes employed with advantage, as a pigment.

APPENDIX TO PHOSPHATE OF IRON.

1. GREEN IRON EARTH. *JAMESON.*

Grüne eisenerde. *Werner.* Fer oxidé terreux. *Haüy.*

No analysis of this substance has been published. *Haüy* has arranged it as an oxide of iron. Others consider it a phosphate of iron.

Its color is green more or less tinged with yellow. It is sometimes indurated, with a dull earthy fracture, yielding a gray streak; but it is usually more or less friable, and stains the fingers.

Before the blowpipe it becomes reddish or brown, but does not melt. According to *Kirwan*, it is not easily soluble in acids.

It is rare; and has been found chiefly at Schneeberg and Braunsdorf in Saxony, in veins with quartz, pyrites, &c. It is sometimes merely a crust.

SPECIES 12. ARSENIATE OF IRON.

Fer arseniaté. *Haüy. Brochant. Brongniart.* Wurfelerz. *Werner.* Hexahedral Olivenite. *Jameson.* Pharmakosiderit. *Hausmann.* Arseniate of Iron. *Aikin. Phillips.*

This rare mineral has an olive green color, more or less deep, sometimes approaching emerald or blackish green, and passing into yellowish brown or brownish green. By decomposition its surface becomes ochreous or reddish brown. Its streak and powder are a pale yellow. It is usually more or less translucent; and is sufficiently hard to scratch carbonate of lime.

It crystallizes in small, shining, well defined cubes, sometimes truncated on the alternate angles, or on the edges, or on all the angles and edges. Sometimes also the alternate angles are replaced by four planes. These cubes are often diagonally striated. The primitive form is by *Haüy* supposed to be a cube.

It is sometimes in stalactites, covered with groups of crystals. Its fracture is uneven or a little conchoidal, and sometimes imperfectly foliated, with a glistening lustre. Its specific gravity is about 3.00.

Arseniate of iron melts even in the flame of a candle. When heated on charcoal before the blowpipe, it melts with ebullition, and exhales a strong odor of arsenic. It contains oxide of iron 48, arsenic acid 18, water 32, carbonate of lime 2. (*VAUQUELIN*.) Chenevix found 9 parts oxide of copper, which, however, he considered accidental.

This ore has been found in the mine of Huel Gorland, &c. in Cornwall, in veins composed of ferruginous quartz, arseniate of copper, sulphuret of copper, arsenical iron, &c. The crystals are attached to the sides of cavities in these veins.—Also at St. Leonhard, in France.

APPENDIX TO ARSENIATE OF IRON.

SKORODITE. *JAMESON*.

Its color varies from leek green to blackish green and liver brown. It is semitransparent, or only translucent at the edges. It is sometimes massive, but more frequently crystallized in broad, rectangular, four-sided prisms, terminated at both extremities by four-sided pyramids, whose faces correspond to the lateral edges. Its structure is foliated in the direction of the broader planes of the prism; its fracture is uneven or imperfectly conchoidal; and its lustre shining and somewhat vitreous. Its hardness is about that of calcareous spar.

Before the blowpipe it melts easily, exhales copious *arsenical* fumes, and is changed into a reddish brown mass, which, when strongly heated, becomes magnetic.

It is found near Schneeberg, in Saxony, in primitive rocks, with quartz and hornstone. Also at Lolling in Carinthia.

Its name is from the Greek *σχοροδων*, *garlic*, in allusion to its odor before the blowpipe.

SPECIES 13. CHROMATE OF IRON.

Fer chromaté. Haüy. Brochant. Brongniart. Chromeisenstein. Werner. Hausmann. Prismatic Chrome ore. Jameson. Chromated Iron. Aikin. Phillips.

The color of this mineral is blackish brown, or nearly black, and sometimes inclines to steel gray. Its powder is gray, or brownish. It is usually opaque; is sufficiently hard to scratch glass; and its specific gravity is between 4.00 and 4.50. Some varieties are not magnetic, unless examined by double magnetism.

It is sometimes in regular crystals, sometimes in grains, and sometimes in amorphous masses of various sizes.

(*Chemical characters.*) Before the blowpipe it is infusible by itself; but with borax yields a beautiful and lively green glass.—This property is very characteristic, and will distinguish it from magnetic iron, or any of the dark colored oxides of iron or uranium, and from dark brown blende. The color of its powder will also serve to distinguish it from magnetic iron.

An amorphous specimen from France yielded Vauquelin oxide of iron 34.7, chromic acid 43.0, alumine 20.3, silex 2. In another from Siberia, Laugier found oxide of iron 34, oxide of chrome 53, alumine 11, silex 1.—It does not appear to be yet determined, whether the chrome is uniformly in the state of an acid, or of an oxide. Berzelius considers it an oxide.

Var. 1. CRYSTALLIZED CHROMATE OF IRON. It occurs in regular octaedrons, or double four-sided pyramids, which are divisible in directions parallel to all the faces;—an octaedron is of course the primitive form.—In some crystals the common base appears to be a rhomb, and in others a rectangular parallelogram.—Sometimes one pyramid is depressed, and sometimes both.

These crystals vary from a size extremely minute, till their faces become nearly one eighth of an inch in length. Their color is nearly black, sometimes with an inclination to steel gray; their faces are smooth and polished, and, when presented to a bright light, often exhibit the colors of tempered steel. They are usually opaque; but, when placed on white paper in the rays of the sun, they sometimes transmit a deep blood red light. Their fracture is more or less conchoidal; their lustre vitreous; and they sensibly move the magnetic needle. (*HAYDEN.*)

This and the following variety have hitherto been found and recognised in the *United States* only;—and for our knowledge of them we are indebted to Messrs. Hayden and Gilmor of Baltimore.

2. GRANULAR CHROMATE OF IRON. It occurs in irregular grains, varying in size from that of a mustard seed to that of a grain of pepper.

3. AMORPHOUS CHROMATE OF IRON. This is found in masses more or less compact, which sometimes resemble dark brown blende.

Its fracture is usually uneven or conchoidal, and sometimes more or less foliated; its lustre is metallic, but feeble, excepting on the faces of the folia, where it is somewhat shining.

(*Geological situation and Localities.*) It is usually imbedded in serpentine, steatite, or slaty talc, to which it sometimes communicates a very beautiful color, nearly peach blossom red, or with a shade of violet. It is sometimes in veins, traversing these rocks.

The amorphous variety was first observed by Pontier, near Gassin, department of Var, in France; its masses are disseminated in serpentine.—Also near Nantz in serpentine.—A variety from the Uralian Mountains presents a texture more foliated, and has a greater lustre, than that from France; its surface exhibits greenish spots of the oxide of chrome.—In Scotland, at Portsoy, and in the islands of Unst and Fetlar in Shetland, it occurs in serpentine.—In Stiria, at Krieglach, in slaty talc.—Also in Bohemia, Silesia, and Piedmont.

In the *United States*. In *Virginia*, near Union in Loudon County. (*COOPER*.)—In *Maryland*, at the Bare Hills, near Baltimore, all its varieties occur, and some of them abundantly, in veins, or in masses, in serpentine.—The crystals are found in channels, worn by water in the sides of the hill, and the serpentine is here traversed by veins of indurated talc. Many of the crystals are injured by attrition. They are mixed with sand and the granular variety.—The granular variety occurs either loose, as already mentioned, or is disseminated in an indurated steatite or serpentine.—The amorphous variety is associated with talc, steatite, &c. in serpentine;—also at Soldier's Delight, near Reistertown, it occurs in serpentine, or loose upon the surface;—in Harford County, it is also found in serpentine or in detached masses, in abundance, and of good quality. It thence extends northeasterly through Pennsylvania, New Jersey, and New York to Milford in Connecticut. (*HARDEN*.)—In *Pennsylvania*, from 10 to 14 miles from Philadelphia, on the West Chester and Lancaster roads, near the Foxchase, &c. in magnesian rocks; it is sometimes in small veins, but more frequently in detached masses in the soil, varying from a few ounces to 20 pounds, and, in one instance, to about 500 pounds in weight. It is sometimes accompanied by magnetic iron, brown hematite, asbestos, &c. (*COOPER. JESSUP*.)—Also at Chestnut Hill, 10 miles from Philadelphia. (*WISTER*.)—In *New Jersey*, at Hoboken, in octahedral crystals in serpentine and other magnesian rocks; it also occurs granular and amorphous.—In *New York*, on Staten island, in steatite; it is sometimes in opaque, black octahedrons, and sometimes granular and amorphous. (*PIERCE & TORRER*.)—In *Connecticut*, near New Haven, on the Milford Hills, disseminated in the marble, which also contains serpentine.—In *Massachusetts*, at Cummington, it occurs compact and amorphous. (*HITCHCOCK*.)—Also at Middlefield, in serpentine. (*EATON*.)

(*Uses*.) This mineral is employed to furnish the chromic acid, which, when united with the oxide of lead, forms chromate of lead, a very beautiful yellow pigment. This pigment, of which there are manufactories at Philadelphia and Baltimore, is sold under the name of *Chromic yellow*, and is employed for painting furniture, carriages, &c.

The Chromate of iron is worth from \$40 to \$60 a ton in market. The chromate of lead in large quantities sells at \$1,00 a pound, and in smaller quantities or by the single pound from \$1,25 to \$1,50. It is stated that, in 1819, about 3000 pounds of the chromate of lead were manufactured in Philadelphia.

SPECIES 14. MURIATE OF IRON.

Fer muriaté. Hauy. Pyrosmalit. Hausmann. Pyrosmalite. Jameson. Phillips.

The color of this rare mineral varies from liver brown to pistachio green or greenish gray. It is translucent at the edges. It occurs in six-sided prisms or tables, whose terminal edges are sometimes truncated. It has a foliated structure in the direction of the sides of the prism; but mechanical division is most easily effected in the direction of the terminal planes. Its laminæ have a shining, pearly lustre; but its cross fracture is uneven or splintery, and only glimmering. It yields to the knife with some difficulty; and its specific gravity is 3.08.

When heated by the blowpipe, it exhales a very strong odor of chlorine or oxymuriatic acid, and is rendered magnetic. It contains, according to Hisinger, submuriate of iron 14.10, protoxide of iron 21.81, protoxide of manganese 21.14, silice 35.85, lime 1.21, water and loss 5.89.

It is found at Nordmark, near Philipstadt, in Sweden, in a bed of magnetic iron, with calcareous spar and hornblende.

A reddish yellow liquid, found in cavities of the lava of Vesuvius, soon after the eruption of 1813, and resulting from the deliquescence of saline substances, yielded Professor Conti muriate of iron 20.00, alumine 10.00, lime 6.14, muriatic acid 9.47, water 53.89.

(*Geological remarks on Iron.*) There is no class of minerals from primitive to alluvial, which does not contain iron; but the different species of ores do not occur indifferently in all classes of rocks. Thus the magnetic and specular oxides of iron, and arsenical iron are found chiefly in primitive mountains, while the argillaceous oxides belong to secondary or alluvial deposits. The red and brown oxides of iron and sparry iron are found in both primitive and secondary rocks.

(*Iron mines.*) Mines of iron occur in all countries; but, it is said, more abundantly in northern than southern latitudes.

In Spain, the most important mines are in Biscay, Catalonia, &c. and yield sparry iron, and the red and brown oxides.

Of France the principal iron ores are sparry iron, brown oxide of iron, specular iron, and the argillaceous oxides.

Great Britain affords the red, and brown, and the argillaceous oxides in abundance.

In Germany, the mines of Eisenerz in Stiria, and Huttenberg in Carinthia are celebrated for the abundance and quality of the iron, they produce. The ores are sparry iron, the brown oxide, &c.

In the island of Elba, near the coast of Tuscany, is one of the most ancient and celebrated mines of iron. The ore, which is the specular oxide, is very abundant, and yields about 65 per cent.

The iron of Sweden is much esteemed. It is obtained chiefly from the magnetic oxide, which is there found abundantly in primitive

mountains.—The mines of Gellivara, in Swedish Lapland, form a mountain about 2600 fathoms long, and from 1000 to 1600 fathoms broad, composed of iron ore in layers sometimes 200 or 300 fathoms thick. The layers are separated from each other by a red and almost compact feldspar, mixed with quartz and mica.

Russia is rich in iron, large quantities of which she obtains from the Uralian Mountains in Siberia.

In the *United States*, ores of iron are abundant. Those hitherto worked are chiefly the magnetic oxide, brown hematite, and the argillaceous oxide, particularly bog ore. The more important ores are the following, viz. in *New Hampshire*, the magnetic oxide;—in *Vermont*, brown hematite, and bog ore;—in *Massachusetts*, bog ore;—in *Rhode Island*, brown hematite;—in *Connecticut*, brown hematite, bog ore, and carbonate of iron;—in *New York*, the magnetic, specular, and argillaceous oxides;—in *New Jersey*, the magnetic and argillaceous oxides;—in *Pennsylvania* and the States south and west, the magnetic oxide, brown hematite, and the argillaceous oxide.

In New York, New Jersey, and Pennsylvania, the ore is found in an abundance and of a quality not exceeded in Sweden. The Connecticut and Virginia iron is highly esteemed.

More than 600 furnaces, forges, and bloomeries now exist in the United States; at which, it is estimated, that about 30,000 tons of bar iron and about 60,000 tons of cast iron are annually made. In 1819, 20,000 tons of iron in bars and bolts were imported into the United States.

For the preceding brief notice of the iron ores, &c. in the United States, the writer is indebted chiefly to a manuscript memoir on *American Mineralogy* by Col. Gibbs.*

In *Ohio*, are furnaces or forges or both in nine or ten counties. The ore sometimes occurs in nodules in clay; and sometimes it is a very ferruginous sandstone, occurring in beds. (*ATWATER.*)

GENUS IX. LEAD.

The color of pure Lead is bluish gray with considerable lustre, but it soon tarnishes by exposure to the air. By friction this metal exhales a peculiar and somewhat disagreeable odor; and, when rubbed on paper or the fingers, it leaves a dark bluish trace. Its specific gravity is 11.35.

Lead is fusible at about 612°; and may be crystallized in octaedrons.—When received into the stomach, it operates as a violent poison.

(*Uses.*) The uses of metallic lead are well known, and considerably numerous. It ought not, however, to be employed in the construction of vessels for containing water, or of pipes for the conveyance of water,

* See also Dr. Beck's Address before the Society for the promotion of Useful Arts; Albany; 1813.

designed for the use of families ; for it appears, that Lead, immersed in water, is gradually oxidated at the common surface of the air and water, and this oxide may eventually be conveyed into the stomach. We must also repeat, that the use of earthen ware, glazed with the oxide of lead, is extremely dangerous. Wine, cider, apple sauce, or any substance containing an acid, or in which an acid may be produced by fermentation, ought never to be preserved in such vessels.

Its oxides and some of its salts are employed in painting—and also in medicine, as external applications. Its oxides, in small quantities, enter into the composition of certain kinds of glass without communicating any color ; but in larger quantities they render glass or enamel yellowish.

Although its ores are considerably numerous, only one species occurs in sufficient quantity to be explored by itself.

SPECIES 1. NATIVE LEAD.

Several instances of the occurrence of Native Lead have been mentioned, though in but few of them does the fact appear to be well established. In the island of Madeira, it is found in small masses, in lava, and has undoubtedly been reduced to its present state by volcanic fire.—According to M. Leschevin, it has also been observed in globules, of the size of a pea, in a gangue, containing the sulphuret and carbonate of iron.

It is also said to have been observed in the *United States* ; in *Ohio*, near the mouth of Au Glaize river, where it forms slips, or slender prismatic masses in crystallized galena. (*STICKNER* in *Sill. Jour.* vol. ii, p. 171.)

SPECIES 2. SULPHURET OF LEAD.

Plomb sulfuré, *Hauy. Brongniart.* Bleiglanz. *Werner. Hausmann.* Lead Glance. *Jameson.* La galene. *Brochant.* Galena. *Aikin. Phillips.*

Galena.

The common color of this ore is that shining bluish gray, usually called lead gray ; sometimes it becomes very dark, and sometimes it is nearly steel gray. Its streak has a metallic lustre, but its fine powder is nearly black. It is easily broken, and may be cut by a knife. Its specific gravity is about 7.58.

Its structure is commonly foliated, sometimes granular, or compact, and sometimes striated or fibrous. It occurs in regular crystals ; but is more frequently massive. Its crystals and laminated masses divide with great ease by percussion into little cubes, thus discovering the primitive form, of which M. *Hauy* has described several modifications.

The primitive cube is liable to truncation on its edges and angles, and is sometimes elongated.—Another of its secondary forms is a regular octaedron, sometimes cuneiform, and often truncated on its edges, or solid angles, or on both. In addition to truncations upon the angles, each edge is sometimes bevelled, and even the edges of these bevelments truncated.—Sometimes also the four edges, lying between the planes of the octaedron and the truncations on the solid angles, are also truncated, or each solid angle is replaced by five planes.—Other forms are mentioned, some of which seem to arise merely from a greater or less extent of certain faces.

(*Chemical characters.*) Before the blowpipe it usually decrepitates, and, on charcoal, is decomposed and melted, yielding a globule of metallic lead. It is essentially composed of lead and sulphur. A specimen, analyzed by Westrumb, yielded lead 83.00, sulphur 16.41, silver 0.08; =99.49. From another, Dr. Thomson obtained lead 85.13, sulphur 13.02, silver 0.5; =98.65. In a specimen from St. Genevieve, Dr. Meade has found lead 72, sulphur 24, silex and oxide of iron 4, with a trace of silver. The same ore yielded Schoolcraft 82 per cent. of lead. A mean of 4 analyses by Vauquelin gives 67.5, sulphur 17.0, lime and silex 15.5.

It very often contains a little silver. Sometimes indeed the silver is in the proportion of 10, 20, 40, or even more than 100 ounces to a ton of the ore. It is then worked as an ore of silver, and called *Argentiferous Galena*. Those varieties of Galena, which contain the most silver, do by no means possess the highest lustre, nor the palest color; on the contrary, they are sometimes blackish gray.—Galena may also contain variable proportions of antimony, bismuth, and sometimes of iron, which increases its hardness. It is sometimes contaminated by silex and lime; indeed some varieties do not yield more than 50 or 60 per cent. of lead.

(*Distinctive characters.*) Its greater specific gravity and some other obvious characters distinguish it from graphite and sulphuret of molybdena.—It streak, unlike that of the sulphuret of zinc, is metallic and shining.

Var. 1. COMMON SULPHURET OF LEAD OR GALENA.* Its color is lead gray, but has sometimes a tinge of black, or is beautifully irised. It presents the crystalline forms already described, but usually occurs in laminated masses; sometimes also in plates, or is reticulated, corroded, botryoidal, reniform, &c.—Its structure is foliated, presenting laminæ of various sizes, which sometimes resemble *scales*, lying in all directions. Sometimes the laminæ are curved. Its lustre is metallic, frequently

* Plomb sulfuré laminaire. *Haüy. Brongniart.* Gemeiner Bleiglanz. *Werner.* Common Lead Glance. *Jameson.* La Galene commune. *Brochant.* Common Galena. *Kirwan.*

splendent, but sometimes moderate. When broken, it falls into cubical fragments. Its specific gravity is sometimes a little above or below that already stated.

When the mass is composed of minute glimmering scales, it is sometimes nearly or quite *friable*.

2. GRANULAR SULPHURET OF LEAD.* This variety presents itself in masses, composed of granular concretions more or less minute, sometimes resembling the grain of steel. It forms a passage from the common to the compact variety.

3. COMPACT SULPHURET OF LEAD OR GALENA.† Its color is usually a little lighter than that of the common variety, and sometimes passes to steel gray. Its grain is very fine; its texture close and compact; and its fracture even, or a little conchoidal with a moderate but metallic lustre.—It occurs in masses, or nodules, and is sometimes specular.

It often contains a considerable proportion of silver.

SPECULAR GALENA.‡ *Aikin. Phillips.* This subvariety presents a smooth, polished surface, variable in lustre, but often resembling that of a mirror. It usually forms a mere coat on other minerals.—It is sometimes called *Slickensides*.

It is found in Derbyshire, often in veins of quartz. In these veins, two surfaces of quartz, coated with specular galena, are found contiguous, but there is very little adhesion between them. When they are separated, or broken through by a blow, a loud explosion often takes place, sometimes detaching large fragments of the vein.—It occurs also at Bleyberg in Carinthia.

4. STRIATED SULPHURET OF LEAD.§ Its fracture presents diverging striæ, which are sometimes large and broad, and sometimes plumous. This structure is supposed to arise from the presence of sulphuret of antimony.—It is sometimes reticulated.—Sometimes it invests common Galena.

SUBSPECIES 1. ANTIMONIAL SULPHURET OF LEAD.

Plomb sulfuré antimonifère. *Hauy.* Plomb sulfuré antimonie. *Brongniart.* Bournonite. *Jameson. Phillips.* Triple sulphuret of lead, antimony and copper, or Endellione. *Bournon.* Spiessglanzbleierz. *Hausmann.* Triple sulphuret of lead. *Aikin.*

Its color is between dark lead gray and steel gray. It slightly scratches carbonate of lime, but is easily broken. Its specific gravity is between 5.5 and 5.8.—It occurs both amorphous, and crystallized in rectangular four-sided prisms, or elongated cubes, often modified

* Plomb sulfuré granulaire. *Hauy.* Granular Galena. *Aikin. Phillips.* Also Steel grained Galena.

† Plomb sulfuré compacte. *Hauy. Brongniart.* Bleischweif. *Werner. Hausmann.* Compact Lead Glance. *Jameson.* La Galene compacte. *Brochant.* Compact Galena. *Kirwan. Aikin. Phillips.*

‡ Plomb sulfuré speculaire. *Hauy.*

§ Plomb sulfuré strié. *Hauy. Brongniart.* Variety of Common Lead Glance. *Jameson.* Radiated Galena. *Aikin.*

on the angles or edges. The crystals are usually grouped, and sometimes intersect each other. Its fracture is uneven or conchoidal with a metallic lustre.—Sometimes, however, it is striated or fibrous; and probably many specimens of the striated variety belong to this subspecies.

Before the blowpipe it is fusible, with the escape of white fumes, into a dark gray globule, whose interior is composed of metallic copper. A specimen, analyzed by Hatchett, yielded lead 42.62, antimony 24.23, sulphur 17.0, copper 12.8, iron 1.2;=97.85.

In Cornwall, near Endellion, it is associated with the sulphurets of antimony and zinc. It occurs also in Bavaria, Saxony, &c.

SUBSPECIES 2. ARGENTO-ANTIMONIAL SULPHURET OF LEAD.

Plomb sulfuré antimonifere et argentifere. *Haüy. Weissgultigerz. Werner. White silver. Jameson. Aikin. Phillips. Weissgiltigerz. Hausmann.*

Its color varies from a light lead gray to nearly iron black. Its fracture is usually even, with a moderate lustre. It yields with ease to the knife; and its specific gravity extends from 5.3 to 5.6. Its fracture is usually even, with a moderate lustre.—Some specimens exhibit delicate fibres, indicating the presence of sulphuret of antimony.

Before the blowpipe it melts, exhaling fumes, and leaves a globule of impure silver, surrounded by a yellow powder. In a specimen of the dark colored variety from near Freyberg, Klaproth found lead 41.0, antimony 21.5, silver 9.25, sulphur 22.0, iron 1.75, alumine and silex 1.75;=97.25. In a specimen of the lighter colored variety he found lead 48.06, antimony 7.88, silver 20.40, sulphur 12.25, iron 2.25, alumine and silex 7.25;=98.09.

Near Freyberg, it occurs in veins traversing gneiss, with the common sulphuret of lead, red silver, and sulphuret of antimony.

SUBSPECIES 3. ARGENTO-BISMUTHAL SULPHURET OF LEAD.

Wismuthisches silber. *Selb. L'Argent bismuthifere. Bismuthic Silver. Jameson. Aikin. Phillips. Silberwismuthierz. Hausmann.*

This subspecies has a light lead gray color, an uneven fracture, and a glistening metallic lustre.

When exposed on charcoal to the action of the blowpipe, small globules of bismuth flow from it, and communicate to borax an amber yellow with reddish spots. (*KLAPROTH* in Brochant.)—A specimen, analyzed by Klaproth, yielded lead 33.0, bismuth 27.0, silver 15.0, sulphur 16.3, iron 4.3, copper 0.9;=96.50.

It has been found chiefly in Schwarzwald, in gneiss.

SUBSPECIES 4. ARSENICAL SULPHURET OF LEAD.

Its color is a metallic gray. It yields to the knife, is very brittle, and has a vitreous fracture. In one direction its structure is tabular or foliated. Its powder is red.

Before the blowpipe it melts easily ; and, when heated in a tube, a red sublimate appears, which becomes yellow by cooling.

It is found in Upper Valais in Switzerland, in granular magnesian limestone with pyrites, red sulphuret of arsenic, &c.

For our knowledge of this subspecies we are indebted to James Smithson, Esq.

SUBSPECIES 5. COBALTIC SULPHURET OF LEAD.

Kobaltbleierz. Hausmann. Cobaltic Lead Glance. Jameson.

Its color is a shining lead gray. It occurs in very minute crystals, aggregated in groups ; and sometimes it is disseminated in very small masses. Its structure is foliated or scaly.

Before the blowpipe it splits, and gives to borax a smalt blue color.

It is found in a vein near Clausthal in the Harz ; and also in Catalonia.

(*Geological remarks on Sulphuret of Lead.*) This species occurs in primitive and transition mountains, but is more frequently found in secondary rocks, especially in compact limestone. Its beds sometimes alternate with shell limestone. It has also been found in beds of coal, and its veins sometimes contain bitumen.

Sulphuret of lead constitutes beds and veins, both of which are sometimes very extensive. Its more common gangues are quartz, sulphate of barytes, and the carbonate and fluuate of lime.

It is almost always accompanied by the sulphuret of zinc, and frequently by other ores of zinc and lead, by pyritous copper, sulphuret of iron, and sometimes by red silver, &c. &c.—Jameson remarks, that the sulphuret of lead, which occurs in veins, contains more silver, than that, which exists in beds.

(*Localities.*) Sulphuret of lead is found more or less in every country. It is, however, said to be rare in the Uralian Mountains, and in Peru, two countries abounding with other ores. We shall mention but few foreign localities.

In France, at Huelgoet and Poullaouen, this ore is found in large veins in primitive rocks ;—and at La Croix, in the Vosges, it is disseminated in a vein of granite.—At Tarnowitz, in Silesia, it occurs in grains, nodules, or veins, contained in a bed of brown ferruginous marl, which is undulated, the concave parts being richer in ore, than those, which are convex. This marl rests on horizontal beds of compact limestone, containing shells and asphaltum, and is also covered by a bed of compact limestone, containing calamine and brown oxide of iron ; above this are beds of marl, clay, and sand.—In Scotland, at Strontian, in veins traversing gneiss ;—at the Lead Hills in Lanarkshire, its veins traverse transition rocks, and also contain carbonate, phosphate, and

sulphate of lead.—In England, Galena is very abundant. In the Counties of Northumberland, Durham, Derbyshire, &c. its veins traverse compact limestone. In Derbyshire, the veins are irregular in direction and width, but seldom or never penetrate the rock, which covers them. Its gangue is the fluete and carbonate of lime, sulphate of barytes, &c.

Friable Galena occurs in the mines of Freyberg in Saxony.—In the mines of Dufton, England, is found an earthy, friable, bluish gray variety of Galena, which takes fire and burns, when presented to the flame of a candle. It is by some considered a supersulphuret of lead.

In New Spain, district of Zimapan, in veins traversing limestone.

In the *United States*. In *Arkansas Territory*, on James river, 20 miles above its junction with Findley river. The Osage indians smelt the ore, and obtain bullets. (*SCHOOLCRAFT*.)—In *Missouri*, in the Counties of Washington, St. Genevieve, Jefferson, and Madison. The ore is found in an alluvial deposite of stiff, red clay, which is often marly, and contains numerous, detached masses of quartz, there called the *blossom of lead*; this alluvion, which varies from 10 to 20 feet in depth, rests on limestone, which appears to belong to the transition class. This Galena, which has usually a broad foliated structure, and a very high lustre, occurs in masses of various sizes, in veins, and beds, and is most abundant in the marly clay. It is associated with sulphate of barytes, calcareous spar, quartz, and blende. Although the number of mines is 45, the limestone, on which the alluvial rests, has been penetrated in but very few instances. The ore yields, on an average, from 60 to 70 per cent. and the average annual product of these mines is upwards of 3,000,000 pounds of lead.—Galena is, in fact, found in various places from Arkansas river to the Northwestern Territory, in which are the important lead mines of Prairie du Chien, now imperfectly worked by the Sacs and Foxes, the original owners of the soil. (*SCHOOLCRAFT*.) The deposite of Galena, in which the mines of Missouri are situated, is evidently one of the most extensive and important, hitherto discovered.—In *Illinois*, on Peter's creek; it is sometimes in cubes with truncated angles. (*JESSUP*.)—In *Kentucky*, at Millersburg, in limestone. (*SCHOOLCRAFT*.)—In *Indiana*.—In *Ohio*, on the south side of Licking creek between Newark and Zanesville, and on the north side of the Ohio river between Indian Wheeling and Campaign creek near Gallipolis. (*ATWATER*.)—In *Tennessee*, near Nashville.—In *Virginia*, Wythe County, near New river, in veins traversing limestone, and sometimes in a gangue of sulphate of barytes. (*SHEFFER*. See this locality under Carbonate of lead.)—In *Maryland*, near Baltimore, forming a vein in primitive limestone. (*GILMOR*.)—Near Libertytown and Taneytown is found an *antimonial* sulphuret

of lead. (*HARDEN.*)—In *Pennsylvania*, on Perkiomen creek, 23 miles from Philadelphia; this sulphuret, sometimes granular, is accompanied by the carbonate, phosphate, molybdate, and sulphate of lead, yellow blende, several ores of copper, and the scaly red oxide of iron. The shaft of this mine is about 170 feet deep, and a horizontal drift, about 300 feet long, enters the shaft 80 feet below the surface. (*CONRAD. WETHERILL.*) This mine, according to Lea, is in the old red sandstone formation.—Also on Conestoga creek, 9 miles from Lancaster, in limestone, accompanied by the carbonate of lead, calamine, &c. (*CONRAD.*)—Also in Bald Eagle valley, in limestone.—In *New York*, Columbia County, in Livingston's Manor, in veins, sometimes large, traversing a slaty rock, and associated with blende, pyrites, pyritous copper, malachite, sulphate of barytes, &c. This ore, sometimes foliated, and sometimes steel grained, yields from 70 to 80 per cent. It is sometimes *argentiferous*. (*SCHAEFFER.*) When all varieties of the ore are melted together, one ton is said to have yielded 118 ounces of silver.—Also at Ancram, where the ore is very rich.—Also at Claverack a vein has recently been discovered. (*GIBBS.*)—Also in Ulster County, on the west side of Shawangunk Mountain, sometimes with blende, and fine crystals of quartz. (*PIERCE & TORREY.*)—Also at Rhinebeck, &c. in Dutchess County, and Greenbush in Rensselaer County. (*MITCHILL.*)—Also at Amenia.—In *Connecticut*, near Middletown, where a mine was formerly opened;—also at Southington, in a vein, associated with pyritous copper in a gangue of sulphate of barytes and quartz;—also at Huntington, where it occurs foliated in a gangue of quartz with native silver, &c.; it is uncommonly *argentiferous*, and, in one experiment, the metallic lead, obtained from this Galena, yielded $3\frac{1}{2}$ per cent. of malleable silver;—also at Bethlehem; its structure is partly foliated, partly granular, and partly fibrous or striated. (*SILLIMAN.*)—In *Vermont*, at Thetford and Sunderland. (*HALL.*)—In *Massachusetts*, Hampshire County, at Southampton, about 8 miles S. W. from Northampton. This vein of Galena traverses granite or other primitive rocks, and is inclined at about 12° or 15° to the horizon; it is 6 or 8 feet in diameter, and extends at least 20 miles, from Montgomery to Hatfield. The fracture of this ore sometimes presents broad laminae; and sometimes the folia are so small, that its structure appears granular. The bulk of the vein is quartz, in which the ore is disseminated in masses, which are sometimes less than an inch, and sometimes more than a foot, in diameter. This quartz, sometimes very beautifully crystallized, frequently presents a radiated structure, resulting from its great tendency to crystallize; it is sometimes intermixed with sulphate of barytes and fluuate of lime. This ore affords from 50 to 60 per cent. of lead, and contains

only $12\frac{1}{8}$ oz. of silver to the ton. (*SILLIMAN.*)* The same vein also contains the sulphate, molybdate, muriate, and phosphate of lead, pyritous copper, and blende.—Also at Leverett, where a vein of Galena and pyritous copper, sometimes in nearly equal proportions, in a gangue of sulphate of barytes and quartz, traverses granite. (*HITCHCOCK.*)—In *Maine*, at Topsham in granite, and at Thomastown in limestone.

(*Remarks.*) Most of the lead of commerce is obtained from this species; and usually contains a little silver.—Galena, in the north of England, yields, on an average, $11\frac{1}{2}$ ounces of silver to a ton. The Galena of the South Hoo mine, near Beeralstone, in Devonshire, has yielded 135 ounces of silver to a ton.

The annual produce of all the lead mines of Great Britain is between 45,000 and 48,000 tons of lead, and is obtained chiefly from Galena.

Galena is sometimes employed for glazing pottery; and hence called *Potter's Lead ore*.

SPECIES 3. OXIDE OF LEAD.

Plomb oxidé rouge. *Haüy.* Native Minium. *Jameson.* *Aikin.* *Phillips.*

The occurrence of lead in the state of a pure Oxide is very rare. The existence, however, of a native *Red Oxide of Lead* appears to be well established.

Its color is a lively scarlet red. It occurs in a loose state, or in masses, composed of flakes with a crystalline texture.—When gently heated, it becomes darker, and, by a stronger heat, on charcoal, is reduced.—It is supposed to proceed from the decomposition of sulphuret of lead, which is said to be sometimes found at the centre of its masses.

It is found in the lead mines of Breylau in Westphalia, disseminated in calamine with galena and carbonate of lead;—also in Yorkshire.

SUBSPECIES 1. ALUMINOUS OXIDE OF LEAD.

Hydrous aluminate of Lead. *Smithson.* Plomb Gomme of some.

The nature of this rare mineral was first ascertained by *Smithson Tennant*.

Its color is yellow; but, in its other external characters, it very strongly resembles the variety of hyalite, found at Francfort on the Main, and sometimes called *Muller's glass*.

When slowly heated, it becomes white and opaque; but is infusible. If suddenly heated, it decrepitates violently. With borax it melts into a transparent colorless glass, and, by the addition of nitre, the lead is reduced. (*SMITHSON.*) It contains, according to *Berzelius*, oxide of

* See *Bruce's Min. Jour.* vol. i; and *North American Review*, No. 3, vol. i.

lead 40.14, alumine 37.0, water 19.9, oxides of iron and manganese 1.8, sulphuric acid 0.2, silex 0.6 ;=99.64.

It is found at Huelgoet, near Poullaouen, in Bretagne.

It has been by some considered a compact wavellite.

SPECIES 4. CARBONATE OF LEAD.

Plomb carbonaté *Haüy. Brongniart. Weiss Bleierz. Werner. White lead ore. Kirwan. Le Plomb blanc. Brochant. Di-prismatic Lead Spar. Jameson. Bleiweiss. Hausmann. Carbonate of Lead. Aikin. Phillips.*

The color of this very beautiful metallic salt is generally white, either pure, or mixed with gray, yellow, green, or brown, and sometimes it is gray, or silver white. The surface is sometimes lead gray, in consequence of partial reduction, or the formation of a sulphuret of lead. It is sometimes limpid and transparent, and sometimes only translucent, or even opaque. Its crystals exhibit double refraction in a high degree. Its specific gravity usually lies between 6.0 and 7.2. It is very brittle, and easily scratched by a knife.

It is often crystallized; and is sometimes *massive*, or in plates or spangles, like mica. It also occurs in *compact*, reniform, or amorphous masses, or in a friable state. Its structure is more or less distinctly foliated, and, by mechanical division, a rectangular octaedron is obtained, as the primitive form of its crystals. Its fracture is usually conchoidal with small cavities, sometimes also uneven, or splintery; its lustre, which may be splendid or only glimmering, is most frequently adamantine or resinous.

Some of its more common secondary forms are the following.—A cuneiform octaedron, which in fact resembles a four-sided prism, bevelled at its extremities by planes, which stand on the obtuse lateral edges.—A six-sided prism, subject to several modifications; sometimes its terminal edges are truncated—sometimes it is terminated by six-sided pyramids, like quartz—and sometimes by only four faces (Pl. V, fig. 15.), two of which stand on opposite lateral faces, and meet in an edge under an angle of $141^{\circ} 02'$, while the other two faces stand on two opposite lateral edges.—A double six-sided pyramid, sometimes with truncated summits.—Sometimes its prisms are tabular.—The crystals are usually small, with highly polished faces, whose lustre is often waxy or adamantine.

(*Chemical characters.*) It is soluble, with effervescence, in nitric acid, especially when diluted; and is rapidly blackened by the action of gas from solutions of alkaline sulphurets. Before the blowpipe it decrepitates, and on charcoal is easily reduced to a globule of lead. A specimen from the Lead Hills, Scotland, yielded Klaproth lead 77, oxygen 5, carbonic acid 16, water 2. In a transparent specimen from Nertschinsk, John found oxide of lead 84.5, carbonic acid 15.5.

(*Distinctive characters.*) Its high specific gravity, its change of color by the action of alkaline sulphurets, and its easy reduction to metallic lead sufficiently distinguish it from the carbonate of lime and sulphate of barytes, the last of which it sometimes much resembles.

Var. 1. ACICULAR CARBONATE OF LEAD. PHILLIPS.* This occurs in delicate needles or prisms, sometimes insulated, and sometimes united in fascicular groups. Their lustre is very often strong and silky; and their surface is sometimes coated with malachite in a state of powder.—Few minerals present finer specimens, than this variety, which comes from the mines of the Harz, &c.

2. COLUMNAR CARBONATE OF LEAD.† Its masses are composed of minute prisms or columns, often channelled, variously aggregated, and intersecting each other. It much resembles columnar sulphate of barytes, with which it is sometimes associated.

3. EARTHY CARBONATE OF LEAD.‡ AIKIN. PHILLIPS. This variety has, in general, a stony or earthy aspect. It occurs in amorphous masses, or reniform concretions, more or less compact, and is sometimes friable, or in tender crusts, or is even pulverulent. Its fracture is uneven, earthy, or splintery, sometimes glossy or resinous, but, in general, nearly dull. It is usually opaque; its color is gray, or grayish white, or shaded with yellow, green, or red, and even passes to pale or greenish yellow, or reddish brown, &c. chiefly in consequence of impurities. Its specific gravity is usually between 4.16 and 5.78.

Some varieties appear to be a pure carbonate and effervesce freely with acids, while others are impure, and effervesce more slowly. A specimen, analyzed by John, yielded oxide of lead 66.0, carbonic acid 12.0, water 2.2, silex 10.5, alumine 4.7, oxides of iron and manganese 2.2;=97.6.

Some specimens, referred to this variety, scarcely effervesce in cold nitric acid, and, with muriatic acid, yield the odor of chlorine; thus indicating that they exist in the state of an oxide rather than that of a carbonate.

(*Geological situation.*) Carbonate of lead, though never in sufficient quantities to be explored by itself, is not uncommon in those mines, which contain the sulphuret of lead. It is, of course, associated with the various substances, found in those mines, and is sometimes intermixed with the blue and green carbonates of copper. Sometimes it appears in silver white spangles on the surface of other minerals, or invests them as a coat.

* Plomb carbonaté aciculaire. *Haüy. Brongniart.* † Plomb carbonaté bacillaire. *Haüy. Brongniart.*

‡ Plomb carbonaté terreux. *Haüy.* Plomb carbonaté massif, et oxidé terreux. *Brongniart. Bleierde, Werner. Hausmann. Earthy Lead Spar. Jameson.*

Its color is sometimes pale green or blue, arising from the presence of green or blue carbonate of copper, forming the *Plomb carbonaté cuprifere* of *Hauy*. Sometimes the color is only superficial, and sometimes it penetrates the mass.

(*Localities.*) It is found in the Harz; at the Lead Hills in Scotland; in the mines of Cornwall, &c. Fine crystals come from the mines of Gazimour in Siberia.—The cupreous variety is found at the Lead Hills in Scotland; in Spain, &c.

In the *United States*. In *Missouri*, at Mine à Burton, incrusting galena. (*SCHOOLCRAFT.*)—In *Illinois*, at Cave in Rock.—In *Virginia*, Wythe County, 14 miles from the Court House, on the banks of New River. It is sometimes massive and coherent, and sometimes disseminated and friable, and is usually yellowish, reddish, or blackish. Galena and other ores of lead occur in this mine; but the Carbonate of lead, at present, predominates in the proportion of 5 to 1 over all the others. The veins, which contain the Carbonate, are sometimes intersected or turned aside by limestone or other rocks. It yields, when pure, about 75 per cent. and, in 1812, about 450 tons of lead were obtained. (*SHEFFER.*) It is sometimes in groups of white, acicular crystals. (*MITCHILL.*)—In *Pennsylvania*, at the Perkiomen lead mine, it is crystallized in six-sided prisms, truncated on the terminal edges—in double six-sided pyramids with truncated summits—and in oblique-angled four-sided prisms, with bevelled extremities; it also occurs compact, and is sometimes penetrated by acicular crystals of red oxide of copper. (*WETHERILL.*) It is sometimes in large plates with bevelled edges. (*WISTER.*)—Also on Conestoga creek, near Lancaster. (*CONRAD.*)

SUBSPECIES 1. BLACK CARBONATE OF LEAD.

Schwarzbleierz. *Werner*. Black lead ore. *Kirwan*. Plomb noir. *Brongniart*. Black Lead Spar. *Jameson*. Bleischwarze. *Hausmann*.

Its color is grayish black or black with considerable lustre, especially in certain parts. It is nearly or quite opaque, and its streak is grayish, sometimes with a tinge of blue.—It is easily scratched by a knife, or broken; and its fracture is uneven or imperfectly conchoidal, with a moderate lustre slightly metallic. It often soils the fingers.—It is amorphous, or occurs in six-sided prisms, or in acicular crystals. Its specific gravity is about 5.75.

Before the blowpipe it decrepitates, and is easily reduced on charcoal. According to *Lampadius*, it contains lead 75.0, oxygen 3.5, carbonic acid 18.0, water 2.0, carbon 1.5. The original color appears to have undergone an alteration, similar to that, produced by the action of alkaline sulphurets or sulphuretted hydrogen on the white

carbonate of lead.—The same specimen is sometimes black on one side, while the other side remains in the state of a white carbonate. (*SILLIMAN.*)

It is found on the surface, or in the cavities, of other ores of lead. It is usually associated with the common carbonate and sulphuret of lead, the latter of which it often incrusts, being at the same time covered by the former.

SPECIES 5. CARBONATED MURIATE OF LEAD.

Plomb muriaté. *Brochant. Brongniart.* Corneous Lead. *Jameson.* Hornblei. *Werner. Hausmann.*
Muriate of Lead. *Aikin. Phillips.*

Its color is light green, greenish yellow, pale yellow, or yellowish gray, and sometimes it is whitish or colorless. It is translucent, and sometimes more or less transparent. It is brittle, and may be scratched by carbonate of lead. Its specific gravity is 6.06.

It is usually crystallized in short four-sided prisms, which are often very nearly cubes. The edges and angles are liable to truncation, and the lateral edges are sometimes bevelled. In some cases, the prism is terminated by four-sided pyramids, whose faces correspond to the lateral planes, and whose summits are sometimes deeply truncated.

Its structure is foliated in three directions, parallel to the planes of a rectangular prism. Its cross fracture is conchoidal; and its lustre is strong, either vitreous or somewhat adamantine.—It is sometimes amorphous.

(*Chemical characters.*) When its powder is thrown into nitric acid, a small portion only of it is dissolved. On charcoal before the blowpipe it melts, and, by continuing the heat, the muriatic acid is disengaged in vapor, and globules of metallic lead appear. It is composed, according to Klaproth and Chenevix, of oxide of lead 85.5, muriatic acid 8.5, carbonic acid 6.

Its crystalline form, inferior hardness, and chemical characters will serve to distinguish it from carbonate of lead.

(*Localities.*) It accompanies the sulphuret of lead, and was first observed in Derbyshire.—In the *United States.* In *Massachusetts*, at the lead mine in Southampton, it occurs on galena, in groups of very light green, and nearly transparent crystals. They have a cubic form, and are terminated by tetraedral pyramids. (*MEADE.*)

SPECIES 6. SULPHATE OF LEAD. JAMESON.

Plomb sulfaté. *Hauy. Brongniart.* Blei vitriol. *Werner. Hausmann.* Le Vitriol de plomb natif.
Brochant. Sulphate of Lead. *Aikin. Phillips.*

This mineral, sometimes massive, usually occurs in small, shining crystals. Its color is white, grayish white, or gray, sometimes tinged with yellow, blue, green, or red. It is sometimes limpid and trans-

parent, and sometimes only translucent. It is easily scraped by a knife, or reduced into fragments. Its fracture is conchoidal or splintery, and has usually a high lustre, either vitreous or adamantine. Its specific gravity lies between 6.2 and 6.3.

The primitive form of its crystals, under which it sometimes appears, is an octaedron. The common base of the two pyramids is rectangular, two of its opposite edges presenting angles of $101^{\circ} 32'$, and the other two, angles of $76^{\circ} 12'$. Haüy has described several modifications.—According to Phillips, the primitive form is a right prism, with rhombic bases of $103^{\circ} 42'$ and $76^{\circ} 18'$.

The aforementioned octaedron is often elongated and cuneiform, its summits being formed by a line in the direction of the obtuse edges of the common base.—Sometimes the obtuse edges of the common base are truncated; in addition to which the solid angles about this base are sometimes bevelled, and even the edges of these bevelments truncated. (Pl. V, fig. 16.)—Sometimes the summits of the elongated octaedrons are so deeply truncated, that the crystal assumes a tabular aspect.

(*Chemical characters.*) It is insoluble in nitric acid. On charcoal it is easily reduced by the blowpipe; indeed the surface of a fragment may be reduced to a metallic state by the flame of a candle. It contains oxide of lead 70.5, sulphuric acid 25.75, water 2.25; = 98.5. (KLAPROTH.)

It sometimes contains carbonate of lead, which increases its specific gravity, and causes a slight effervescence in nitric acid.

Its chemical properties sufficiently distinguish it from the carbonate of lead, which it often much resembles in its external characters.—It is much more easily reduced, than the molybdate of lead.

(*Localities.*) This substance, which is still rare, accompanies the sulphuret of lead, by the decomposition of which it may have been produced.—In the island of Anglesea, it occurs in the cavities of a cellular and friable, reddish brown oxide of iron.

In the *United States*. In *Pennsylvania*, at the Perkiomen lead mine, it occurs in octaedrons, sometimes elongated, and sometimes with truncated summits; some of its crystals are unusually large. (WETHERILL.)—In *Connecticut*, at Huntington, with argentiferous galena. (SILLIMAN.)—In *Massachusetts*, at the Southampton lead mine, it occurs in plates or tables on cubes of sulphuret of lead, and not unfrequently in cavities of quartz, which is the gangue of the sulphuret. It is white, with a strong vitreous lustre, in some parts translucent, in others transparent. Its specific gravity is 6.2. (MEADE.) The molybdate, and some other salts of lead occur in the same vein.

SPECIES 7. PHOSPHATE OF LEAD.

Plomb phosphaté. *Haüy. Brongniart.* Braun and Grun bleierz. *Werner.* La Mine de plomb brune et verte. *Brochant.* Rhomboidal Lead Spar. *Jameson.* Pyromorphit. *Hausmann.* Phosphate of Lead. *Aikin. Phillips.*

Few metallic salts present so many colors, as the Phosphate of lead. Its most common color is some shade of green, sometimes a pure grass green, sometimes pistachio, olive, or blackish green, and sometimes it passes to greenish or sulphur yellow, or even to greenish white; some varieties are gray, often tinged with yellow or brown, and others are brown, or reddish brown, &c. Its powder, however, is usually gray, sometimes with a slight tinge of yellow. It is commonly translucent, sometimes transparent, and sometimes opaque.

It is sometimes amorphous, or in crusts, or in reniform or botryoidal concretions, but is most frequently crystallized. Its crystals are regular six-sided prisms, sometimes truncated on the lateral or terminal edges. This prism may also be terminated by six-sided pyramids, whose faces correspond to the lateral planes, forming with them an angle of $130^{\circ} 53'$. The edges between the prism and pyramid are sometimes truncated.—These prisms are usually short, sometimes even tabular, with shining surfaces, and often with a waxy lustre; the brown varieties, however, have less lustre, their surface being often rough and blackish. Sometimes the lateral faces of the prisms converge toward their extremities.—The crystals are sometimes acicular.—They are often grouped.

Its fracture is uneven or splintery, glistening with a resinous lustre. It is easily broken; but is sufficiently hard to scratch carbonate of lead. Its specific gravity lies between 6.27 and 7.20.

(*Chemical characters.*) Phosphate of lead does not effervesce in nitric acid, although soluble therein. Before the blowpipe it melts into a grayish globule, which, on cooling slowly, presents a polyedral form, whose faces, when examined by a microscope, often exhibit concentric striæ; but it is not reducible even on charcoal without the addition of soda or some other flux. The brown variety, when melted, forms acicular crystals, while cooling, and a radiated mass remains. A specimen of the green Phosphate yielded Klaproth oxide of lead 77.10, phosphoric acid 19.0, muriatic acid 1.54, oxide of iron 0.10; =97.74. From a brown crystal, he obtained oxide of lead 78.58, phosphoric acid 19.73, muriatic acid 1.65; =99.96. It usually contains a little muriatic acid.

(*Distinctive characters.*) The peculiar globule, which it yields before the blowpipe, is very often a good distinctive character. Its want of effervescence in nitric acid will distinguish it from the carbonate of lead and the green carbonate of copper.

ACICULAR PHOSPHATE OF LEAD.* It occurs in acicular crystals, usually short, and diverging in little groups. Sometimes they are very minute, and resemble the surface of velvet, or a kind of moss, and invest other minerals.

(*Localities.*) Phosphate of lead, like the carbonate of lead, with which it is often associated, is found in mines, which contain the sulphuret of lead, whether in primitive, transition, or secondary mountains; and of course it has the same gangues and accompanying minerals, as the sulphuret. Scotland, England, Germany, and France afford good specimens.

In the *United States*. In *Pennsylvania*, at the Perkiomen lead mine, sometimes in grass green six-sided prisms, and sometimes in reniform concretions, or crusts. (*WETHERILL.*)—In *Massachusetts*, it is said to exist in the Southampton lead mine.

SUBSPECIES 1. ARSENIATED PHOSPHATE OF LEAD.

Plomb phosphaté arsenifère. *Hauy*. Arseniated Phosphate of Lead. *Phillips*.

Its color is yellow of different shades, or yellowish green more or less deep, and sometimes with a tinge of brown. It is sometimes crystallized in the forms belonging to the species, and sometimes occurs in reniform or botryoidal concretions, with a fibrous structure. Its fracture is conchoidal with a resinous lustre.

Before the blowpipe it exhales the odor of arsenic, and yields a globule, like the pure Phosphate. It contains oxide of lead 76.0, phosphoric acid 13.0, arsenic acid 7.0, muriatic acid 1.75, water 0.5; =98.25. (*KLAPROTH.*)

It has been found at Roziers in France—in Saxony, &c. and often invests quartz.

APPENDIX TO PHOSPHATE OF LEAD.

BLUE LEAD. JAMESON.

Blaubleierz. *Werner*. Hausmann. Plomb sulfuré épigène prismatique. *Hauy*. Plomb noir. *Brongniart*.
Blue Lead. *Aikin*. *Phillips*.

Its color is darker than lead gray, and approaches indigo blue or bluish black. Its streak has a metallic lustre. Though sometimes massive, it occurs most commonly in opaque, six-sided prisms, with rough, dull surfaces, and sometimes with convex faces.—It is easily broken, and its fracture is in part foliated, and in part even, uneven, or conchoidal, with a feeble metallic lustre. Its specific gravity is 5.46. (*GELLERT.*)

The prisms of Blue lead are sometimes invested, and sometimes more or less deeply penetrated, by sulphuret of lead in shining laminae.

* Plomb phosphaté aciculaire. *Hauy*. Plomb phosphaté briolide. *Brongniart*.

Before the blowpipe it melts, yielding a feeble bluish flame and a sulphurous odor. That part of the prism, which appears to be sulphuret of lead, is reduced to metallic lead, while the remaining part crystallizes, on cooling, in dodecaedrons, without suffering any change of color, and is Phosphate of lead. (*SILLIMAN.*)

Some mineralogists consider this ore an original mixture of the sulphuret and phosphate of lead, while others believe it to be a phosphate of lead, which has, by some process, exchanged a part of its phosphoric acid and oxygen for sulphur.

It is a rare mineral. At Huelgoet, in France, it is associated with the phosphate and sulphuret of lead; and at Zschoppau, in Saxony, with the phosphate and carbonate of lead, malachite, &c.

SPECIES 8. ARSENATE OF LEAD. JAMESON.

Plomb arsenié. *Haüy.* Brongniart. Bleibluthe. *Hausmann.* Arseniate of Lead. *Aikin.* *Phillips.*

Although this species is rare, it has presented considerable diversity of external characters. Its colors are pale yellow, greenish or brownish yellow, hair brown, yellowish green or even grass green, and sometimes yellowish white. It is tender and easily broken. Its specific gravity usually lies between 5.06 and 6.41.

It occurs in six-sided prisms, whose terminal edges are sometimes truncated; but more frequently its crystals are acicular; they are often translucent, and, when transparent, their angles scratch glass.—Small prisms are sometimes so grouped, as to exhibit the general aspect of a six-sided prism, whose sides are curved.—Sometimes it is in hexagonal or rounded plates, grouped in the form of a rose.—Sometimes it is in delicate filaments with a silken lustre, slightly flexible, and reducible to powder by mere pressure.—Sometimes it is in semitransparent grains with a resinous aspect, collected into mammillary or botryoidal masses.—Sometimes it is in opaque reniform concretions with a glistening conchoidal fracture, somewhat resinous.—In fine, it sometimes presents a compact texture; or appears in friable earthy crusts.

(*Chemical characters.*) Before the blowpipe, on charcoal, it is reduced to metallic lead, and exhales the odor of arsenic, which may also be perceived, when its powder is thrown on hot coals. In nitric acid it does not effervesce. A specimen from Saxony yielded Rose oxide of lead 77.50, arsenic acid 19.05, muriatic acid 1.50, oxide of iron 0.25; = 98.30. Another from Cornwall yielded Gregor oxide of lead 69.76, arsenic acid 26.40, muriatic acid 1.58, with a little oxide of iron, silex, and alumine.—It is still uncertain, whether the arsenic, in some specimens referred to this species, is not in the state of arsenious rather than arsenic acid.

A comparison of its chemical characters with those of the other salts of lead will, in general, serve to distinguish it from any of them, it may resemble.

Var. 1. RENIFORM ARSENIATE OF LEAD. JAMESON.* This variety occurs in opaque, reniform masses, whose fracture is more or less conchoidal, with a glistening, resinous lustre. Its color is brownish red; but, by exposure to the atmosphere, its surface becomes ochre or straw yellow. Its specific gravity is only 3.9.

When exposed to the blowpipe on charcoal, it yields the odor of arsenic, and melts into a black globule, containing grains of metallic lead. It contains oxide of lead 35.0, arsenic acid 25.0, water 10.0, oxide of iron 14.0, silex 7.0, silver 1.15, alumine 2.0;=94.15. (*BINDHEIM.*)

It is found near Nertschinsk in Siberia.

(*Localities of the Species.*) It occurs in metallic veins, especially those of sulphuret of lead. Near Saint-Prix in France, it is in acicular crystals, or silken filaments, associated with sulphuret of lead, quartz, &c.—In Andalusia, in botryoidal clusters in a gangue of feldspar and quartz.—In the mines of Cornwall, it occurs in veins, containing the ores of copper, &c.; it is sometimes in six-sided prisms, attached to quartz. In Devonshire, it occurs in the Beeralstone lead mines.

Brongniart has mentioned a mineral, composed of oxide of lead 22, oxide of arsenic 38, oxide of iron 39. Its texture is compact, and its fracture smooth, like that of jasper.† Its color is yellowish brown, and that of its powder ochre yellow. It is fusible, and, when melted on charcoal, exhales the odor of arsenic, and becomes obedient to the magnet. It converts the muriatic into the oxymuriatic acid.—Its locality is unknown.

SPECIES 9. CHROMATE OF LEAD.

Plomb chromaté. *Hauy, Brongniart, Rothbleierz, Werner, Red Lead Spar, Jameson, Le Plomb rouge, Brochant, Kallochrom, Hausmann, Chromate of Lead, Aikin, Phillips.*

Its color is a very beautiful hyacinth or aurora red; but its streak and powder are nearly orange yellow. It is translucent, and sometimes almost transparent. It is easily broken, and may be scraped even by the finger nail. Its structure is foliated. Its fracture is generally uneven, and its lustre somewhat shining. Its specific gravity extends from 5.75 to 6.10.

Though sometimes massive, or in thin plates, it is usually in crystals, whose general form is a rectangular four-sided prism, more or less modified. Sometimes this prism is terminated at each extremity by four faces, making with the lateral planes, on which they stand, an angle of $143^{\circ} 18'$.—Sometimes all the lateral edges are truncated, or

* Bleiniere. *Hausmann.* Reniform Arseniate of Lead. *Aikin, Phillips.* † Plomb oxidé jaspoide.

only two of them ;—and sometimes the prism is terminated by three-sided summits.—Sometimes both extremities are obliquely bevelled, and, when the prism is short, it has a rhomboidal aspect.—The primitive form is an oblique four-sided prism with rhombic bases.—The form of these crystals is frequently incomplete and difficult to determine, although their faces are often well defined and possess considerable lustre. The sides are often longitudinally striated.

(*Chemical characters.*) It does not effervesce in nitric acid, but gives to muriatic acid a green tinge in the course of a few hours. (*HAUR.*) It is fusible by the blowpipe ;—it tinges borax green, and is in part reduced. It contains oxide of lead 64, chromic acid 36. (*THENARD.*) The brown variety, brought from Mexico by Humboldt, contains, according to Descotils, oxide of lead 74.20, chromic acid 16.0, oxide of iron 3.5, muriatic acid 1.5 ;=95.20.

(*Distinctive characters.*) There are several *red* ores, which this Chromate may more or less resemble. But the red sulphuret of arsenic yields the odor of garlic, when heated—the red sulphuret of mercury has a red powder, and may be volatilized by the blowpipe—and the red sulphuretted antimonial silver has also a red powder and yields a globule of silver. In fine, no one of the preceding three tinges borax green.—It is easily distinguished from the red oxide of copper.

(*Geological situation and Localities.*) This ore has been found chiefly in Siberia, near Catharinenberg, in the gold mine of Berezof. It is there disseminated in a metallic vein, traversing gneiss and mica slate ; its gangue is quartz, and it is associated with the sulphuret of lead, the hepatic sulphuret of iron, containing gold, and with the cupreous Chromate of lead.—A little north of this mine, it occurs in the fissures of sandstone, or even in beds of clay, which alternate with this sandstone ; here also it is accompanied by a similar sulphuret of iron, containing gold.—In Brazil, near Cocaes, it occurs in sandstone, associated with a greenish mineral. (*MAWE.*)—A brown Chromate of lead has been brought from Zimapan, in Mexico, by Humboldt.

(*Uses.*) This ore is sometimes employed as a paint, particularly in Russia. It mixes well with oil, and yields a fine color, which is durable in the air. The native Chromate is scarce. But an artificial chromate of lead is manufactured at Philadelphia, the chromic acid being obtained from the Baltimore chromate of iron. (See Chromate of iron.)

SUBSPECIES 1. CUPREOUS CHROMATE OF LEAD.

Plomb chromé. *Brongniart.* Chromite of Lead. *Phillips.* Vauqueline. *Berzelius.*

It occurs in acicular crystals, which appear to be six-sided prisms, or in botryoidal masses, or in a powder, attached to crystals of the Chromate of lead, or to their gangue. Its color is green, sometimes

mixed with yellow or brown; and it preserves its shade of green, when exposed to the action of the fire.

It tinges borax green, and gives to nitric acid a red color, shaded with orange. It contains, according to Berzelius, oxide of lead 60.87, chromic acid 28.33, oxide of copper 10.80.

It accompanies the Siberian Chromate of lead.

SPECIES 10. MOLYBDATE OF LEAD.

Plomb molybdaté. *Haüy. Brongniart.* Gelbes Bleierz. *Werner.* Yellow Lead Spar. *Jameson.* Le Plomb jaune. *Brochant.* Bleigelb. *Hausmann.* Molybdate of Lead. *Aikin. Phillips.*

Its color is ordinarily wax yellow, but varies to lemon or greenish yellow, orange yellow, or yellowish brown. It is usually more or less translucent, at least at the edges, but is sometimes opaque. It is brittle, easily yielding to the knife; and its specific gravity is about 5.48. Its structure is imperfectly foliated. Its fracture is uneven or imperfectly conchoidal, and has usually a glistening, waxy lustre.

It most commonly occurs in crystals, whose general form is tabular or octahedral. The primitive form, which it sometimes presents, is an octahedron or double four-sided pyramid with isosceles triangular faces, any two of which, belonging to opposite pyramids, contain, at the common base, an angle of $76^{\circ} 40'$. It has not less than 9 secondary forms. The primitive octahedron is sometimes truncated on its summits, or on the solid angles about the common base, or on all its solid angles, or on its lateral edges, or several of these modifications may combine (Pl. V, fig. 17.)—Sometimes it occurs in rectangular four-sided tables, or parallelipeds, which in some instances become cubes. The paralleliped may be truncated on its terminal edges. The table may be bevelled on its edges or narrow faces, or be converted by truncation into an eight-sided table (Pl. V, fig. 18.), which may suffer still further modification.—Sometimes the table has 12 sides.

The tables are frequently grouped, and often intersect each other. Their surface, though often shining, is sometimes dull.

This ore also occurs in lamellæ or plates; and sometimes it is amorphous with a compact texture.—It is sometimes merely a crust.

(*Chemical characters.*) Before the blowpipe it decrepitates, and melts into a gray or dark colored mass, which, by urging the heat, discovers globules of lead. It is soluble in hot nitric acid without effervescence, unless carbonate of lime be accidentally present. According to Klaproth, it contains oxide of lead 64.42, molybdic acid 34.25; =98.67.

(*Distinctive characters.*) From carbonate of lead it may be distinguished by its want of effervescence in nitric acid, by its more difficult reduction before the blowpipe, and usually by its color.—Sulphate of lead, it will be recollected, is very easily reduced—and phosphate of lead is not reducible by the blowpipe, but yields a polyedral globule.

(*Geological situation and Localities.*) At Bleyberg in Carinthia, and at Zimapan in Mexico, it occurs on compact limestone, and at the former place is accompanied by other ores of lead. It is sometimes associated with sulphuret of molybdena. It occurs also near Brixlegg in the Tyrol, and Annaberg in Austria.

In the *United States*. In *Pennsylvania*, at the Perkiomen lead mine, where it is finely crystallized in small quadrangular tables with beveled edges, or with truncated angles, or with both modifications; its colors are orange and wax yellow; and it is associated with other salts of lead. (CONRAD. WETHERILL.)—In *Massachusetts*, at the Southampton lead mine, in small tabular crystals of a dark wax yellow, attached by their edges to cavities of crystallized quartz, and frequently intersecting each other. The sulphate and other salts of lead occur in the same mine. (MEADE.)

SPECIES 11. TUNGSTATE OF LEAD.

Its exterior much resembles certain varieties of acicular phosphate of lead. It crystallizes in very acute four-sided pyramids. (HEULAND.) It is found at Zinnwald in Bohemia.

GENUS X. TIN.

The color of pure Tin is less white than that of silver, being slightly tinged with gray. It has more lustre and malleability, and is harder, and more tenacious than lead. It is very flexible, and when a small bar or plate of this metal is bent, a peculiar crackling sound is heard. Its specific gravity is 7.29.

It melts at about 442° Fahr. By exposure to the air it loses its lustre, but, at common temperatures, is scarcely, if in any degree, oxidated by air and moisture. When melted, however, it readily attracts oxygen from the air.

(*Uses.*) These are numerous and important. With mercury it forms the compound, applied to the back of mirrors or looking glasses. With copper it constitutes *bronze*, *bell metal*, *gun metal*, &c. It enters into the composition of pewter and soft solder.—It is employed in the preparation of *tin-plate*, which consists of iron, whose surface is *tinned* to prevent oxidation. It is also applied to the surface of copper vessels, designed for the preparation of food, to prevent the injurious effects, arising from the copper; but it does by no means render the use of such vessels safe.

The oxides of Tin are difficultly fusible, and enter into the composition of enamels and glasses, to which they communicate an opaque white.—Muriate of Tin is employed in dying.

This genus embraces only two species; for there is not sufficient evidence, that native tin has ever been observed.

SPECIES 1. OXIDE OF TIN. PHILLIPS.

Étain oxidé. Haüy. Brongniart. Zinnstein. Werner. Hausmann. Tinstone. Kirwan. Aikin. La Pierre d'étain. Brochant. Pyramidal Tin ore. Jameson.

This ore has but little of a metallic aspect. Its colors vary from blackish brown and black to brown, yellowish or reddish brown, or nearly red, and even to yellowish gray, greenish or grayish white. Its streak and powder are gray, or grayish white. It is sometimes opaque, and sometimes almost transparent, according as its color is dark or light. Its specific gravity lies between 6.30 and 7.00. Few oxides have so high a specific gravity, when compared with that of the pure metal.

It has the hardness of feldspar, and gives fire with steel, but is easily broken. Its structure is imperfectly foliated; and it yields to mechanical division in directions parallel to the sides and diagonals of a rectangular four-sided prism. Its fracture is uneven or a little conchoidal; and its lustre is shining in various degrees, and resinous, or sometimes nearly vitreous.

This Oxide is found amorphous, in rolled masses, or in grains, and very often in crystals, whose primitive form appears to be an octaedron or double four-sided pyramid with square bases. The angle at the common base of the octaedron is about $67^{\circ} 42'$. Its secondary forms are numerous; but the crystals are often so much grouped, that it is difficult to perceive their form.

Its general form is a rectangular four-sided prism, whose edges are liable to truncation or bevelment.

This prism is sometimes terminated by four-sided pyramids, whose faces make with the lateral planes, on which they stand, an angle of 135° ; it is sometimes truncated on the lateral edges. (Pl. V, fig. 19.); and sometimes the lateral edges are bevelled. When the prism is short, this crystal may be viewed as an octaedron, truncated on the common base, and is sometimes so described.—The same four-sided prism may be terminated by pyramids, whose faces stand on the lateral edges.—Sometimes this prism is terminated, at each extremity, by an eight-sided pyramid, whose vertex is formed by only four planes (Pl. V, fig. 20.), which stand on the most obtuse edges of the pyramid, and correspond to those faces, which terminate the first mentioned variety.—The most common form, however, is a hemitrope or twin crystal, composed of two halves of crystals incorporated together, and presenting on one side a reentering angle more or less large. These hemitropes are most frequently composed of crystals, belonging to the variety of form first described. (Pl. V, fig. 21.)—The surface of the crystal has often a strong lustre.

(*Chemical characters.*) Before the blowpipe it decrepitates, and its powder, strongly heated for some time on charcoal, may be reduced

to metallic tin. It is sometimes contaminated with arsenic or iron. A specimen from Cornwall yielded Klaproth tin 77.50, oxygen 21.5, silex 0.75, iron 0.25.

It sometimes contains columbium. In a specimen from Finbo, Berzelius found oxide of tin 93.6, of columbium 2.4, of iron 1.4, of manganese 0.8; =98.2.

(*Distinctive characters.*) Its hardness, which enables it to give sparks with steel, may serve to distinguish it from the sulphuret of zinc and ferruginous tungsten, both of which have a lamellar structure.—The powder of calcareous tungsten in nitric acid becomes yellow, which is not the case with that of the Oxide of tin.

(*Geological situation.*) The Oxide of tin appears to belong exclusively to primitive rocks, although it is frequently found in the state of grains or sand in alluvial deposits, which have arisen from the disintegration of primitive rocks. It is found even in the oldest formations, as granite, gneiss, mica slate, &c. in which it is disseminated, or exists in irregular masses, or beds, or more frequently in veins, which traverse these rocks. It is accompanied by arsenical iron, the oxide and other ores of copper, the ores of tungsten, sulphuret of molybdena, &c. also by quartz, topaz, the fluuate and phosphate of lime, hornblende, mica, &c. It is seldom or never connected with carbonate of lime or sulphate of barytes.—Its grains adhere to other substances, or appear in the form of sand.

Tin is evidently one of the oldest metals. It is disseminated in the oldest rocks; and its veins are always *intersected* by those of other metals, when they occur together.

(*Localities.*) Tin is a very rare metal; and in many extensive countries has not yet been found. The most ancient and celebrated mines of tin appear to be those of Cornwall, in England. The Oxide of tin is there disseminated in granite, or exists in veins, traversing granite and other primitive rocks, or is found in alluvial earths. The tin ore of Cornwall is usually found in crystals more or less aggregated; and it is often the case that different veins furnish different varieties of form.—In the alluvial deposits, the Oxide of tin is found in crystals or fragments of crystals, either separate or imbedded in some rock, and varying in size from grains to masses 3 or 4 inches in diameter. These deposits are sometimes called *Stream works*, because the ore is separated from other alluvial matter by the action of running water; and the ore itself is also called *Stream tin*.—Some of the tin mines of Cornwall extend under the sea; and that of Huel-Cock is so near the bottom of the sea, that the noise of the waves and the rolling of the pebbles may be distinctly heard. (*BRONGNIART.*)

Tin is also found in Galicia in Spain, in veins traversing granite and mica slate.—Also in Bohemia and Saxony, on both sides of the

Erzgebirge, either disseminated in granite, or in veins, traversing granite and other primitive rocks.—In Sweden, at Finbo, it occurs in blackish octaedrons or grains in quartz, and contains variable proportions of *columbium*.—Also in France, near St. Leonhard, in a vein traversing granite, and containing also arsenical iron, ferruginous oxide of tungsten, &c.—Also in Ireland, County of Wicklow, in alluvial deposite.—In Asia, it is found in Malacca, Banca, Sumatra, Siam, &c.—In Mexico, it occurs in alluvial deposite.

(*Remarks.*) This Oxide is the only ore of tin, which occurs in sufficient quantity to be explored. The *Block tin* of commerce is obtained from the Oxide of tin, found in veins, or disseminated in rocks, and is less pure, than *Grain tin*, which is obtained from the ore found in alluvial deposite, and called *Stream tin*. (*TAYLOR.*)—In 16 specimens of metallic tin from Cornwall, Thomson found, on an average, only $\frac{1}{1000}$ part of copper, and from $\frac{1}{1000}$ to $\frac{1}{10,000}$ part of iron.

SUBSPECIES 1. FIBROUS OXIDE OF TIN. PHILLIPS.

Etain oxidé concretionné. *Hauy. Brongniart.* Kornishches Zinnerz. *Werner.* Wood Tin. *Jameson.*
Kirwan. Aikin. Fasriger Zinnstein. *Hausmann.*

Its color is hair brown, light or dark, or nearly chestnut brown, which passes into reddish brown or yellowish gray. It is opaque; easily broken; and its specific gravity is between 6.30 and 6.73.

It occurs in small masses more or less globular, reniform, or wedge shaped, &c. Its structure is fibrous; and its masses, when broken, present delicate, diverging fibres with a feeble resinous lustre. Its fibres are sometimes intersected by undulated, parallel, lamellar concretions or zones.

Before the blowpipe it becomes brownish red, but is neither fusible nor reducible. A specimen from Cornwall yielded Vauquelin oxide of tin 91, oxide of iron 9. Another from Mexico yielded Descotils oxide of tin 95, oxide of iron 5.

Some specimens are nearly black at the surface and much resemble brown hematite; but the ore of tin has a much higher specific gravity.

This fibrous Oxide is found in Cornwall in alluvial earths.

The variety, called *Toad's eye*, is found in Cornwall in very minute, spherical masses, composed of fibres, radiating from a centre. Its colors are brown and yellowish white in alternate, concentric bands. These masses are imbedded in an aggregate of quartz and schorl, which forms large veins in granite.

The fibrous Oxide of tin is found also in Mexico, either in veins, or alluvial deposite.

SPECIES 2. PYRITOUS TIN.

Etain pyriteux. *Brongniart*. Zinnkies. *Werner*. Hausmann. Tin Pyrites. *Kirwan*. Aikin. *Phillips*.
Etain sulfuré. *Haüy*. La Pyrite d'étain. *Brochant*. Common Tin Pyrites. *Jameson*.

Its color is steel gray, more or less mixed with yellow. Its streak has a metallic lustre, but its powder is blackish. It is always amorphous. It is easily broken, and may be scraped by a knife. Its fracture is usually uneven or granular, sometimes a little conchoidal, with a metallic lustre. Its specific gravity is between 4.35 and 4.78.

Before the blowpipe it yields the odor of sulphur, and melts into a black scoria, but is not reduced. It gives to borax a yellowish tinge, and its powder effervesces in nitric acid. It contains tin 34, copper 36, sulphur 25, iron 2;=97. It is very probably a mixture of sulphuret of tin and pyritous copper.

It has been found only in Cornwall in a vein, where it is associated with pyritous copper and blende.

It is sometimes called *Bell metal ore*.

GENUS XI. ZINC.

Pure Zinc is white, slightly tinged with blue, and has considerable lustre. Its structure is foliated, but its fracture presents broad striæ. Its hardness is such, that it is not easily cut by a knife; and its specific gravity is about 7.00. By uniform pressure between laminating rollers it may be extended into plates; but, at a temperature between 212° and 300° Fahr. its malleability is so much increased, that it may be hammered into thin plates, or even drawn into wire. At a higher temperature, however, it again becomes brittle under the hammer.

By exposure to the air, it loses its lustre, but is very little oxidated. It melts at about 680°; and, in that state, easily combines with the oxygen of the air.—At a higher temperature, it burns with a greenish blue flame, which, by increasing the heat, assumes a brilliant white color, and a white oxide of Zinc is sublimed in the form of very light flocculi.

(*Uses and Remarks.*) Zinc, united with copper, forms *brass*, one of the most useful metallic alloys. It has other less important uses, as in fireworks. Its oxide and salts are sometimes employed in medicine. Its white oxide may be used as a pigment with oil, and is in some respects preferable to white lead.

The ores of Zinc are few; and in some of them the existence of a metal would never be suspected from their external aspect.—The presence of this metal may be determined by roasting the ore, and then fusing it by the blowpipe on charcoal with filings of pure copper. If Zinc be present, the copper will be converted into brass.

SPECIES 1. SULPHURET OF ZINC.

Zinc sulfuré. Haüy. Brongniart. Blende. Werner. Kirwan. Aikin. Phillips. La Blende. Brochant. Dodecahedral Zinc Blende. Jameson. Zink Blende. Hausmann.

Blende.

This ore exhibits a great diversity of external aspect. Its colors may be reduced to three principal varieties, *yellow*, *brown*, and *black*, all of which exhibit different shades, or are more or less tinged with red or green. Its powder is gray, often with a tinge of yellow, or even of brown in the darker varieties. It is sometimes transparent, more frequently translucent, and sometimes opaque.

Its specific gravity usually lies between 3.96 and 4.26. It scratches sulphate of barytes, but not glass, and does not give fire with steel. It is easily frangible.

Its structure and its fracture are almost always more or less distinctly foliated. The laminae separate in six different directions, parallel to the sides of a rhomboidal dodecaedron. Indeed it also yields by mechanical division an octaedron, tetraedron, and rhomb. —The surface of the fracture has most commonly a strong lustre, often splendid, but sometimes feeble; in some cases it is resinous, in others vitreous or adamantine, and sometimes it is metallic.—Its masses present granular distinct concretions of various sizes.

It is sometimes in crystals, sometimes in plates, sometimes in mammillary or reniform concretions, and often massive. Its crystals are often so grouped, that it is difficult to determine their form, and their surface has frequently a very high lustre.

It rarely presents the primitive form of its crystals, which is a dodecaedron with rhombic faces; or it may be viewed as a six-sided prism, terminated at each extremity by three faces, which stand on alternate lateral edges. It has a considerable number of secondary forms.

Sometimes eight solid angles of the primitive form are truncated.—Sometimes it presents a tetraedron, which is liable to truncations on its angles—and sometimes a regular octaedron, which may be truncated on its edges, or solid angles, or on both.—One of its forms (Pl. V, fig. 23.) is complex in its structure; it has 24 faces, of which 12 are trapeziums, and the remaining 12 are isosceles triangles, joined two and two at their bases; sometimes also four of its solid angles are truncated.—Sometimes the crystals are acicular.

(*Chemical characters.*) Before the blowpipe it usually decrepitates, and, though generally infusible even with borax, it sometimes melts into a scoria. Its powder in sulphuric acid yields the odor of sulphuretted hydrogen gas. The yellow variety afforded Bergman zinc 64, sulphur 20, water 6, iron 5, fluoric acid 4, silex 1. From the brown variety Dr. Thomson obtained zinc 58.8, sulphur 23.5, iron 8.4, silex 7.0; = 97.7.

A lead colored specimen, from Perkiomen creek in Pennsylvania, whose specific gravity was 5.31, yielded Woodhouse zinc 72, sulphur 22, iron 3, silex 3. Some chemists suppose the zinc in this ore to exist in the state of an oxide, while others believe it to be in a metallic state. Bergman has suggested, that the union of metallic zinc with sulphur may be facilitated by the iron, which is usually present.—Blende sometimes contains small quantities of gold, silver, lead, arsenic, and *cadmium*.

The fibrous or radiated Blende of Przibram, in Hungary, contains 2 or 3 per cent. of the metal, cadmium, recently discovered by Stromeyer. This metal has also been found in the fibrous Blende, siliceous oxide and carbonate of zinc of Derbyshire.

(*Distinctive characters.*) The streak of Sulphuret of zinc is always dull, while that of the sulphuret of lead is shining and metallic; their powders also exhibit different colors.—Its foliated structure and inferior hardness separate it from the oxide of tin.—It is also less hard, than chromate of iron, and does not tinge borax green.—It is much lighter than the black oxide of uranium.

Var. 1. YELLOW SULPHURET OF ZINC, OR BLENDE.* Its more common colors are wax or wine yellow, and sulphur yellow; sometimes also it is hyacinth or brownish red, or even green with a tinge of yellow. It is translucent, and sometimes transparent, like resin.

Its crystals, both externally and internally, exhibit a strong lustre, which is usually more or less adamantine. When rubbed or scraped by a hard body, even under water, it is usually phosphorescent in the dark, and exhales the odor of sulphuretted hydrogen gas. Some specimens must be rubbed with a steel point, while in others the point of a quill is sufficient to produce phosphorescence.—It occurs both massive and crystallized.

It is one of the rarest varieties of Blende.—Good specimens are found in the Pyrenees, and in Bohemia.

2. BROWN SULPHURET OF ZINC, OR BLENDE.† This is the most common variety of Blende. Its color is brown, more or less tinged with red or yellow, and is sometimes blackish brown. It sometimes presents tarnished colors. It is seldom quite transparent, most frequently translucent, at least at the edges, and is sometimes opaque.

It occurs both massive and crystallized; and its fracture has a lustre nearly resinous, often strongly shining, but sometimes only glimmering.

* Zinc sulfuré jaune. *Brongniart*. Gelbe Blende. *Werner*. Hausmann. Yellow Blende. *Kirwan*. La Blende jaune. *Brochant*. Yellow Zinc Blende. *Jameson*. Phosphorescent Blende. *Aikin*. *Phillips*.

† Zinc sulfuré brun. *Brongniart*. Braune Blende. *Werner*. Hausmann. Brown Blende. *Kirwan*. La Blende brune. *Brochant*. Brown Zinc Blende. *Jameson*.

3. BLACK SULPHURET OF ZINC, OR BLENDE.* Its colors are black, grayish, brownish, or reddish black. It is often irised, and usually opaque, but sometimes transmits a blood red light at its edges.

It occurs both massive and crystallized; and its fracture is often less distinctly foliated, than that of the preceding varieties. Its lustre is strong and usually metallic.—It sometimes resembles a dark sulphuret of lead.

4. FIBROUS SULPHURET OF ZINC.† Its color is dark reddish brown, grayish or yellowish brown, or iron black. It is opaque, or a little translucent at the edges. Its streak is reddish brown; and its specific gravity is about 3.63.

It is usually in reniform or tuberous masses. Its structure is fibrous; and its fracture, which is dull, or has only a feeble lustre, presents very delicate, diverging fibres or striæ. It also exhibits curved lamellar concretions.—By friction it yields the odor of sulphuretted hydrogen.

Before the blowpipe it decrepitates, burns with a blue flame, and yields the odor of sulphur.

It is a rare variety. It is sometimes imbedded in common brown Blende. At Geroldseck in Brisgaw, it occurs in clay, in a vein of sulphuret of lead.—In Cornwall, with pyritous copper and carbonate of iron.

(*Geological situation.*) Sulphuret of zinc, which seldom forms an entire vein by itself, is very common in other metallic veins in primitive and transition rocks; it occurs also in secondary rocks, especially compact limestone. It is almost constantly associated with the sulphuret of lead, frequently with the sulphuret of iron, pyritous copper, and sometimes with sulphuret of silver, brown hematite, sparry and magnetic iron, &c.—It is sometimes in beds. Its gangues are usually quartz, carbonate and fluuate of lime, and sulphate of barytes. Jameson remarks, that the yellow variety belongs to the oldest formation of Blende.

(*Localities.*) It is unnecessary to enumerate foreign localities. Rammelsberg, near Goslar, furnishes large quantities of zinc, either in a metallic state, or in that of an impure oxide, obtained while roasting ores, which contain Blende.

In the *United States*. In *Missouri*, in some of the lead mines.—In *Maryland*, near Baltimore, the yellow variety occurs with galena in gneiss. (*HARDEN.*)—In *Pennsylvania*, at the Perkiomen lead mine, are found the yellow, brown, and black varieties. At Webb's mine, 24 miles from Northumberland, yellow Blende is imbedded in calcareous

* Zinc sulfuré noir, *Brongniart*. Schwarze Blende. *Werner*. Hausmann. Black Blende. *Kirwan*. La Blende noire. *Brochant*. Black Zinc Blende. *Jameson*.

† Zinc sulfuré strié. *Hauy*. Zinc sulfuré compacte. *Brongniart*. Fasrige braune Blende. *Werner*. Fibrous brown Zinc Blende, *Jameson*. Schaa-len-blende. *Hausmann*. Fibrous Blende. *Aikin*. *Phillips*.

spar. (*CONRAD.*)—In *New Jersey*, at Hamburg, Blende is associated with magnetic iron—and at Sparta, the yellow variety is accompanied by graphite.—Also at Schuyler's mines.—In *New York*, near Hamilton College, it occurs in beautiful, wax yellow, and nearly transparent crystals;—at Shawangunk Mountain, it is brown;—and in the Highlands, it occurs black, opaque, nearly dull, and resembling some varieties of hornblende. (*PIERCE & TORREY.*)—Near Niagara Falls, it is yellow in fetid limestone. (*MORTON.*)—In Columbia County, at Livingston's lead mine.—In *Connecticut*, at Berlin, it is yellow, with galena in a vein, which appears to traverse sandstone or greenstone. (*SILLIMAN.*)—In *Massachusetts*, at the Southampton lead mine, it occurs both massive and finely crystallized; it is sometimes yellow.—Also at Leverett, where it is yellowish, in a vein of galena and pyritous copper, traversing granite. (*HITCHCOCK.*)

(*Uses.*) This ore cannot be so easily explored, nor economically reduced, as calamine. It has, however, in a number of places, when previously roasted or calcined, been used in the preparation of brass, and may probably be employed in the manufacture of this useful alloy with more advantage, than has generally been supposed.—It is sometimes converted into Sulphate of zinc or white vitriol.—The miners often call it Black Jack.

SPECIES 2. RED OXIDE OF ZINC. BRUCE.

Red Oxide of Zinc. Jameson. Phillips.

For our knowledge of this *new* species among the ores of zinc we are indebted to Professor Bruce of New York.

Its color is red, either light or dark, approaching blood red, ruby or aurora red. Its powder is brownish yellow, approaching orange. It is generally translucent at the edges.

Its specific gravity is 6.22. Its structure and fracture in one direction are foliated; its cross fracture is slightly conchoidal. Its fresh fracture is shining; but, by long exposure to the atmosphere, becomes dull, and is eventually covered with a pearl white crust. It is brittle, and easily pulverized, or scratched by steel.

(*Chemical characters.*) It is soluble in the nitric, sulphuric, or muriatic acid, yielding a colorless solution. It is infusible by the blowpipe; but with borax melts into a transparent, yellow bead. Before the compound blowpipe it sublimes with a brilliant white light.—Its powder, mixed with potash, melts into an emerald green mass, which communicates to water the same color; but, on the addition of a few drops of nitric, sulphuric, or muriatic acid, the green solution immediately becomes rose red.—It is composed of zinc 76, oxygen 16, oxides of manganese and iron 8. (*BRUCE.*)

In another specimen, Berthier found oxide of zinc 88, red oxide of manganese 12.

(*Distinctive characters.*) It differs from red sulphuretted antimonial silver and from the chromate of lead by its infusibility before the blowpipe;—from the red oxide of copper by its greater specific gravity and by its colorless solution in nitric acid;—from the red oxide of titanium by its solubility in acids;—and it is not, like the red sulphuret of arsenic, volatilized before the blowpipe with the odor of garlic.

(*Geological situation and Localities.*) It is sometimes imbedded in calcareous spar, and sometimes it forms the gangue of magnetic iron, which is either in crystals, or more frequently in irregular grains.—It is found in *New Jersey*, Sussex County, in the Franklin, Stirling, and Rutgers iron mines, and near Sparta. At Franklin, it also assumes a micaceous form, and is imbedded in a whitish oxide of zinc.

(*Remarks.*) This ore is well adapted for the manufacture of the best kind of brass, and may be employed without any previous preparation. It is reduced without difficulty to a metallic state; and may be made to furnish the sulphate of zinc. It is remarked by Professor Bruce, that this ore, “from its abundance, and the many uses, to which it may be applied, promises to be a valuable acquisition to the manufacturing interest of the United States.”

SPECIES 3. FRANKLINITE. BERTHIER.

Although this mineral contains more iron than zinc, yet, for certain reasons, we place it as a provisional species among the ores of the latter metal.

Its general aspect is that of magnetic oxide of iron. Its color is iron black; but that of its powder is deep reddish brown. It occurs in grains, or amorphous masses, which very rarely present some crystalline faces. Its structure is imperfectly foliated; and its fracture uneven or conchoidal. Its specific gravity is 4.87. It is magnetic, but without sensible polarity.

It is easily soluble, without effervescence, in hot muriatic acid, and exhales a slight odor of chlorine. When exposed to a high temperature, the zinc is volatilized, and there remains an iron gray, hard alloy of iron and manganese, impressible by a file, and susceptible of a fine polish. The Franklinite is composed of oxide of zinc 17, of iron 66, of manganese 16. (BERTHIER.)

It is found in the *United States*; in *New Jersey*, and accompanies the red oxide of zinc.

Its name alludes to that of Dr. *Franklin*.

SPECIES 4. SILICEOUS OXIDE OF ZINC.

Zinc oxidé. *Haüy*. Zinc calamine. *Brongniart*. Variety of Galmei. *Werner*. Electric calamine. *Jameson*. Aikin. *Phillips*. Zinkglas. *Hausmann*.

Calamine.

This Oxide has the aspect of an earthy or a stony mineral, rather than that of an ore. Its ordinary colors are grayish white or white, yellowish or bluish gray, pale yellow or greenish, and sometimes brown, reddish or yellowish brown, especially at the surface. Its crystals are sometimes transparent, but the other varieties are only translucent, and sometimes opaque. It scratches carbonate of zinc, but may be scraped by a knife. Some varieties are sufficiently compact to give fire with steel.—Its specific gravity is usually about 3.45. When crystallized, or nearly in a state of purity, it becomes strongly electric by a gentle heat, and preserves its electricity some hours.

It sometimes occurs in lamellæ, or small crystals, whose structure, in one direction, is more or less foliated. One of its more common forms is a six-sided prism, often compressed, and terminated by diedral summits (Pl. V, fig. 22.)—sometimes the solid angles of the summits are also truncated. Sometimes the crystal resembles a four-sided table, bevelled on its narrow faces, and truncated on the solid angles of the bevelments.—It also presents an octaedron.—The crystals, seldom insulated, are usually collected into groups.

This mineral also occurs massive, reniform, mammillary, botryoidal, stalactical, &c. These masses are composed of diverging or radiating fibres, sometimes so fine and close, that the texture appears nearly or quite compact.—The crystals often occur in the cavities of these masses.

In fine, it sometimes occurs in masses with an earthy texture, being mingled with carbonate of zinc, oxide of iron, &c.

(*Chemical characters.*) In nitric acid, this Oxide of zinc dissolves without effervescence, and the solution becomes gelatinous. It is infusible by the blowpipe; but it usually whitens, and, if previously solid and translucent, it becomes opaque and friable. Pelletier found oxide of zinc 38, silex 50, water 12. A specimen, analyzed by Smithson, yielded oxide of zinc 68.3, silex 25.0, water 4.4;=97.7. Another by Klaproth gave oxide of zinc 66, silex 33;=99. When not crystallized, it is sometimes contaminated by carbonate of lime, &c.; and hence may sometimes effervesce with acids.

(*Distinctive characters.*) Its infusibility by the blowpipe sufficiently distinguishes it from the zeolite, which it sometimes resembles in its structure, as well as in becoming electric by heat, and forming a jelly with acids; but the last two properties serve to distinguish it from other minerals, which it may also resemble.

(*Geological situation.*) This ore of zinc occurs in primitive, transition, and secondary rocks, where it exists in metallic veins, or

in beds; and is most frequently found in compact limestone. Its accompanying minerals are the sulphurets of lead and zinc, the brown and argillaceous oxides of iron, &c.

(*Localities.*) This ore exists in extensive beds in the Dutchy of Juliers.—In England, it occurs in Leicestershire, and Derbyshire;—and in Scotland, at Wanlockhead.—Fine crystals come from Friburg, in Brisgaw. Patrin mentions an uncommon variety, found in a lead mine in Daouria. It is in very small, translucent, globular masses, united in clusters; its color is nearly honey yellow, and its surface is chatoyant.

In the *United States*, Calamine has been found in *Pennsylvania*, at the Perkiomen lead mine, and also on Conestoga creek, 9 miles from Lancaster; but the writer knows not, whether it is the siliceous oxide, or the carbonate of zinc.—In *Ohio*, it is said to occur in white plates or laminæ, between strata of compact limestone, near the Falls of the Hockhocking. (*ATWATER.*)

(*Uses.*) Most of the zinc of commerce is obtained from this and the following species, both of which are called *Calamine*; and are also the two ores of zinc, which are chiefly employed in the preparation of *brass*. In this process, the oxide or the carbonate of zinc, previously calcined, is mixed with charcoal and granulated copper, and then exposed to a suitable heat. The color and other properties of the brass depend much on the proportions of the copper and zinc, the latter of which may vary from 15 to 25 per cent.—The pure oxide of zinc is employed in medicine, as an antispasmodic.

SPECIES 5. CARBONATE OF ZINC. PHILLIPS.

Zinc carbonaté. *Hauy. Brongniart.* Variety of Galmei. *Werner.* Rhomboidal Calamine. *Jameson.* Calamine, *Aikin.* Galmei. *Hausmann.*

This species can scarcely be distinguished from the preceding by its external characters, and has long been confounded with it under the common name of *Calamine*.

Its color is gray or white, often with shades of yellow, blue, or green, or is pale yellow, and, when impure, it is brown, brownish yellow, &c. Its specific gravity extends from 3.35 to 4.40. It yields easily to the knife, and is not capable of scratching glass. It is not rendered electric by heat.

It is sometimes in small crystals, whose forms are a rhomb, either acute or obtuse—and a four-sided table, elongated, and sometimes bevelled on its narrow faces. The crystals have an imperfectly foliated structure, and are usually more or less transparent.

More frequently it occurs in compact masses, or in concretions, exhibiting some *imitative* form.

It is sometimes *pseudomorphous*, and appears, in most cases, to have derived its form from double six-sided pyramids of carbonate of lime. These crystals are dull and hollow.

(*Chemical characters.*) It dissolves with effervescence in cold sulphuric acid, or in warm nitric acid; but it does not, like the siliceous oxide of zinc, form a jelly with the latter acid. It is not melted by the blowpipe.—If paper, which has been immersed in a solution of this salt in nitric acid, be dried, and then held at the distance of a few inches from glowing coals, it spontaneously kindles. The crystallized variety from Derbyshire yielded Smithson oxide of zinc 65.2, carbonic acid 34.8. In the compact variety, he found oxide of zinc 64.8, carbonic acid 35.2.

Var. 1. COMPACT CARBONATE OF ZINC, OR CALAMINE.* It occurs in amorphous masses, or reniform, mammillary, or stalactical concretions, and is sometimes cellular, corroded, in crusts, &c. These concretions often present an imperfectly fibrous structure, and sometimes they appear compact. Its fracture is uneven, or splintery, sometimes nearly even, and is either dull or glistening. It is generally opaque, sometimes translucent at the edges. Its color is usually gray, more or less shaded with yellow or green, sometimes pale yellow, or is even rendered brown by oxide of iron.—It sometimes presents curved, lamellar, distinct concretions.

2. EARTHY CARBONATE OF ZINC, OR CALAMINE.† It occurs in opaque masses, with a dull, earthy fracture. Sometimes also it is reniform, botryoidal, or in crusts. It is tender, yields to the nail, and often adheres to the tongue. Its specific gravity is 3.36.

In acids it dissolves more readily than the compact variety. A specimen from Carinthia yielded Smithson oxide of zinc 71.4, carbonic acid 13.5, water 15.1. It is by some considered a hydrous carbonate of zinc.

3. CUPREOUS CARBONATE OF ZINC.‡ It occurs in very thin lamellæ, aggregated, and diverging. It has a satin lustre, and a pale green color, which is attributed to the presence of green carbonate of copper.

This variety is found near Matlock in Derbyshire.

(*Geological situation and Localities.*) This ore, like the siliceous oxide of zinc, is usually found in transition or secondary rocks, and most frequently in carbonate of lime. It occurs in beds or veins, and is associated with sulphuret of lead, ores of copper, &c.

In England, it is abundant, occurring at the Mendip Hills in Somersetshire; at Holywell in Flintshire; and near Castleton in Derbyshire. Near Bristol, &c. it occurs pseudomorphous.—Most of the Calamine in England and Scotland is said to belong to the Carbonate of zinc.—It occurs also in Carinthia, Hungary, and other parts of Europe. Near Limburg in Germany, its crystals exist in a compact oxide of zinc.

In the *United States.* In *Pennsylvania*, at the Perkiomen lead mine, in reniform concretions, radiated, and compact. (*WETHERILL.*)

* Compact Rhomboidal Calamine. *Jameson.* Compact Calamine. *Aikin. Phillips.* Gemeiner Galmei. *Hausmann.*

† Earthy Rhomboidal Calamine. *Jameson.* Earthy Calamine *Aikin. Phillips.* Zinkbluthe. *Hausmann.* Zinc carbonaté hydreux. *Lucas.* ‡ Cuprifereous Calamine. *Aikin. Phillips.*

SPECIES 6. SULPHATE OF ZINC. PHILLIPS.

Zinc sulfaté. *Haüy. Brongniart.* Vitriol of Zinc. *Kirwan.* Pyramidal Vitriol. *Jameson.* White Vitriol. *Aikin.*

White Vitriol.

This salt is rarely found native. It occurs in capillary efflorescences, or in crusts, or in concretions tuberos, reniform, &c. It is sometimes in rectangular, four-sided prisms, terminated by four-sided pyramids. The crystals are often acicular, and aggregated into fibrous masses. It is generally translucent, and its color is white or gray, often shaded with yellow or red.

It has a sharp, styptic taste, and is soluble in water. If unmixed with the sulphate of iron, its solution does not yield a black precipitate on the addition of tincture of galls. A specimen from Rammelsberg yielded Klaproth oxide of zinc 27.5, sulphuric acid 22.0, water 50.0, oxide of manganese 0.5.

The native Sulphate of zinc is found in mines, which contain the sulphuret of zinc, from the decomposition and oxidation of which it proceeds.—In Cornwall, it has been observed in minute shining crystals, yellowish at the surface.

(*Remarks.*) In preparing the *white vitriol* of commerce, the Sulphuret of zinc is roasted, and then exposed to the action of moisture and air. The sulphur is thus converted into sulphuric acid, which, combining with the oxide of zinc, produces the Sulphate. The salt is then extracted by lixiviation, and rapidly crystallized; hence its granular appearance, like white sugar.—It often contains iron, and sometimes a little lead.

This salt is employed in medicine, and operates almost instantly as an emetic, although perfectly safe; and may hence be used, when poison has been swallowed. When the White Vitriol of commerce is employed, it should be purified by dissolving it in water, and adding the filings of zinc, which, by frequent agitation, precipitate the foreign metals.

GENUS XII. NICKEL.

The color of pure Nickel is intermediate between that of silver and platina. When polished, it has a high lustre. Its hardness is but little inferior to that of iron; and when thoroughly hammered, its specific gravity is 8.93. (*TOURTE.*) It is ductile, and may be hammered into very thin plates. In common with iron, it is magnetic, capable of acquiring polarity, and may be formed into permanent magnetic needles.

It is not oxidated by exposure to air or moisture. It is less easily fusible, than iron; and its solution in nitric acid is nearly grass green.

*SPECIES 1. NATIVE NICKEL. JAMESON.*Nickel natif, *Haüy*. Haarkies, *Werner*. Native Nickel, *Phillips*.

Its color is bronze yellow, sometimes inclining to steel gray. It occurs in slightly flexible needles or filaments, which often diverge in groups. It is not magnetic.

It contains a little cobalt and arsenic, the latter of which undoubtedly destroys its magnetism. It has been found in Bohemia, and the Harz.—In Cornwall, it is in cavities of arsenical nickel.

Metallic nickel is also found in all meteoric stones, and is in alloy with iron.

*SPECIES 2. ARSENICAL NICKEL.*Nickel arsenical, *Haüy*. *Brongniart*. Kupfernickel, *Werner*. *Brochant*. *Hausmann*. Prismatic Nickel Pyrites, *Jameson*. Copper Nickel, *Aikin*. *Phillips*.

Its color is copper red, or pale reddish yellow; but it acquires a grayish black tarnish by exposure. It is opaque; and its specific gravity varies from 6.60 to 7.70. It is sufficiently hard to give sparks with steel, and at the same time yields the odor of arsenic.

It is brittle; and its fracture is uneven, or imperfectly conchoidal, sometimes granular, glistening or even shining with a metallic lustre.—It usually occurs in amorphous masses; but is sometimes dendritic, botryoidal, &c. It is said to occur also in four or six-sided prisms.—Some specimens resemble a slag.

(*Chemical characters.*) When heated by the blowpipe, it exhales the odor of arsenic, and is with difficulty converted into a scoria. In warm nitric acid it forms a green solution, in which a greenish deposit shortly appears. It is essentially composed of nickel and arsenic, but usually contains, as unessential ingredients, iron, sulphur, cobalt, &c. A specimen from Riegelsdorf yielded Stromeier nickel 44.2, arsenic 54.7, iron 0.3, lead 0.3, sulphur 0.4;=99.9. A specimen from Allemont yielded Berthier nickel 39.94, arsenic 48.8, antimony 8.0, cobalt 0.16, sulphur 2.0;=98.9. This ore, by long exposure to the atmosphere, exhibits greenish spots, arising from oxidation.

(*Distinctive characters.*) It strongly resembles native copper; but the latter is malleable.—From the tarnished varieties of pyritous copper it may be distinguished by its greenish deposit in nitric acid, and its odor of arsenic before the blowpipe.

(*Geological situation.*) This ore is found most frequently in primitive rocks, where it either constitutes the principal part of the vein, or is disseminated among ores of cobalt, silver, and copper. Its connexion with certain ores of cobalt is very constant, and it is usually accompanied by the oxide of nickel.—Its gangues are quartz, sulphate of barytes, carbonate of lime, &c.

It is the only ore of nickel, which occurs in any considerable quantity.—It is found in Bohemia, Saxony, Cornwall, France, &c.

In the *United States*. In *Maryland*, it is found in the copper mines in Frederick County. (*HARDEN*).—In *Connecticut*, at Chatham, it is reddish yellow with a metallic lustre, and contains, on an average, half its weight of nickel. It is associated with arsenical cobalt in irregular veins, or disseminated in a hornblende rock. (*PIERCE & TORRER*.)

APPENDIX TO ARSENICAL NICKEL.

BLACK NICKEL. JAMESON.

Nickelschwarze. *Hausmann*. Black ore of Nickel. *Phillips*.

Its color is dark grayish or brownish black. It occurs in dull, earthy masses, or crusts, which are easily broken. Its streak has some lustre.

With nitric acid it forms an apple green solution, in which a white precipitate appears.—This mineral probably results from the decomposition and oxidation of arsenical nickel.

It is found at Riegelsdorf, associated with the other ores of nickel, in veins traversing bituminous marlite.

An ore of nickel has been found at Helsing in Sweden, in opaque masses, whose structure resembles that of steel grained galena. Its recent fracture is lead gray or nearly tin white with a high lustre; but it slowly tarnishes, and then resembles Arsenical nickel. Its specific gravity is 6.1. It contains nickel 24.4, arsenic 45.9, iron 10.5, sulphur 12.4; = 93.2. (*PFÄFF*.)

SPECIES 3. ARSENITE OF NICKEL.

Nickel oxidé. *Haüy*. *Brongniart*. Nickel ocker. *Werner*. Nickel ochre. *Kirwan*. *Jameson*. *Aikin*. *Phillips*. L'Ocre de Nickel. *Brochant*.

Its color is apple green, sometimes inclining to grass green; and even when greenish white, its true color appears by immersion in an acid. It almost always occurs in the state of a powder, forming a coat or efflorescence on other minerals.—It has also been observed in dull masses, nearly or quite opaque, with an earthy, even, or conchoidal fracture.

In hot nitric acid it forms a green solution. It is reducible by the blowpipe to metallic nickel with the assistance of borax, which it colors yellowish red. It contains, according to *Stromeyer*, oxide of nickel 37.4, arsenious acid 37.0, water 24.3, oxide of iron 1.1, sulphuric acid 0.2. *Berthier* considers it arseniate of nickel. He obtained oxide of nickel 36.2, arsenic acid 36.8, water 24.5, oxide of cobalt 2.5.—It very probably proceeds from the action of the atmosphere upon arsenical nickel.

It somewhat resembles the green carbonate of copper, and, when ammonia is added to its solution in nitric acid, a pale blue precipitate

is produced ; but, unless copper be present, this blue changes in a few hours to violet, and, on the addition of an acid, the violet gives place to apple green.

It usually occurs as a crust or efflorescence on arsenical nickel, or on the ores of cobalt, or is disseminated in certain earths.

GENUS XIII. COBALT.

This metal, when pure, is grayish white, with a moderate lustre ; but, by long exposure, it acquires a violet or reddish tinge. Its texture is compact and fine-grained. It is hard, brittle, and easily reduced to powder. Its specific gravity is 8.5. (*TASSAERT.*) It is attracted by the magnet.—By exposure to air or moisture it is scarcely oxidated ; and it does not melt at a less heat than 130° W.

(*Uses and Remarks.*) As *metallic* Cobalt has not been applied to any use in the arts, it is seldom reduced to that state, except for chemical experiments. But when extracted from its ores, Cobalt exists in the state of an impure oxide, which is usually grayish. This impure oxide is called *zaffre* ; but, when fused with about 3 parts siliceous sand, and an alkaline flux, it is converted into a *blue* glass, called *smalt*. It is this *zaffre* or *smalt*, which is employed in the arts, to give a fine deep blue to glass, enamel, porcelain, &c. It is from this oxide, that linen derives its bluish tinge.

The presence of Cobalt in any of its ores may be discovered by fusing them with borax or some other alkaline salt, to which they communicate a blue color. Or the ore, supposed to contain Cobalt, may be dissolved in nitromuriatic acid, and letters written with this solution somewhat diluted ;—if it be an ore of Cobalt, the letters, though invisible when cold, will become green, when moderately heated.

SPECIES 1. ARSENICAL COBALT. *AIKIN.*

Cobalt arsenical. *Hauy. Brongniart.* Weisser Speiskobalt. *Werner.* Octahedral Cobalt Pyrites. *Jameson.*
Bright white Cobalt. *Kirwan.* Speiskobalt. *Hausmann.* Tin white Cobalt. *Phillips.*

When recently broken, its color is a shining tin white, or almost silver white, sometimes passing to light steel gray ; but, by exposure to the air, it tarnishes, and assumes a grayish, reddish, or violet tinge.—Its texture is granular, or nearly compact ; its fracture is usually uneven, sometimes a little conchoidal ; and its lustre is metallic and somewhat shining.—It is not easily scratched by steel, but is broken without difficulty. Its specific gravity is between 6.45 and 7.72.

It occurs in amorphous masses, or in reniform, botryoidal, and stalactical concretions, or is reticulated, dendritic, &c. The concretions are sometimes composed of diverging or even radiating fibres. It is sometimes crystallized in cubes, which may be truncated on the angles and edges (Pl. V, fig. 24.) ; and also in octaedrons, either perfect,

or truncated on the solid angles. The crystals have sometimes a smooth and shining surface; but they are often cracked; and their sides are frequently convex.

(*Chemical characters.*) When exposed to the flame of a candle, it yields a white smoke and a very sensible odor of garlic. With the blowpipe, the smoke is more abundant, and the odor more striking. Though difficultly fusible by itself, it melts with borax, to which it imparts a blue color. When immersed in nitric acid, it almost *instantly* produces a considerable effervescence. A crystallized specimen from Riegelsdorf yielded Stromeyer cobalt 20.3, arsenic 74.2, iron 3.4, sulphur 0.9, copper 0.2;=99. In a specimen of the radiated variety, John found cobalt 28.0, arsenic 65.7, oxide of iron 5.0, of manganese 1.3.

(*Distinctive characters.*) Its granular or nearly compact texture, and the odor of garlic, which it exhales by exposure to the flame of a *candle only*, distinguish it from gray cobalt, the following species, which has a foliated structure, and does not, when barely exposed to a candle, exhale the odor of arsenic.—Its *sudden* effervescence in nitric acid, and the blue color, it gives to borax, may prevent it from being confounded with arsenical iron.

*Var. 1. DULL ARSENICAL COBALT.** Its color is commonly a light steel gray, but its surface is usually tarnished, either grayish black, or like tempered steel. It is never crystallized; but occurs amorphous, reniform, &c. Its fracture, though sometimes uneven, is in general nearly or quite even, and is either dull, or has only a feeble lustre. Its specific gravity is sometimes as low as 5.30. (*KIRWAN.*)

Before the blowpipe it yields an arsenical odor, but is said to be difficultly fusible. It contains, according to Klaproth, cobalt 20, arsenic 33, iron 24, the remainder being bismuth and earth.

(*Geological situation and Localities.*) This ore occurs in veins, which more frequently traverse primitive, than secondary rocks. It is associated with other ores of cobalt, and with those of nickel, arsenic, silver, bismuth, and copper. It is disseminated in quartz, carbonate of lime, hornblende, &c.

It is found in Spain, France, Germany, Sweden, Cornwall, &c. Near Dartmoor, England, it is associated with native silver and sulphuret of silver in quartz. (*MAWE.*)—The radiated variety is found at Schneeberg in veins in argillite.

In the *United States*. In *Connecticut*, at Chatham, near Middletown, an ore of cobalt, containing both arsenic and sulphur, is disseminated in a rock, which appears to be composed principally of hornblende and

* Dull gray Cobalt ore. *Kirwan*. Grauer Speiskobalt. *Warner*. Gray Octahedral Cobalt Pyrites. *Jameson*. Cobalt arsenical gris-noiratre. *Haüy*. Gray Cobalt. *Aikin*. *Phillips*.

actynolite. This mine was explored about 40 years since, and the ore exported to England. (*SILLIMAN.*)

(*Remarks.*) This and the following species are the only ores of cobalt, which occur in sufficient abundance to be explored for the purpose of commerce. No mine of cobalt is at present explored out of Europe; and all the smalt or oxide of cobalt, employed in India, proceeds from the mines and manufactories of Germany. (*BRONGNIART.*) Some of the principal mines of cobalt are at Schneeberg, &c. in Saxony; Joachimsthal, &c. in Bohemia; Tunaberg, &c. in Sweden.

SPECIES 2. GRAY COBALT.

Cobalt gris. *Hauy, Brongniart.* Glanzkobalt. *Werner.* Hexahedral Cobalt Pyrites. *Jameson.* Le Cobalt eclatant. *Brochant.* Bright white Cobalt. *Kirwan, Aikin, Phillips.* Kobaltglanz. *Hausmann.*

When recently broken, its color is a shining metallic white, or silver white with a slight tinge of red; but it gradually tarnishes with shades of gray, &c.

Its structure is more or less distinctly foliated, and its crystals possess natural joints, parallel to the faces of a cube. It is not very easily broken, is sufficiently hard and compact to give fire with steel, and, at the same time, exhales the odor of arsenic. Its specific gravity varies from 6.33 to 6.45. Its fracture, especially in amorphous specimens, is sometimes imperfectly foliated, or even striated. Its lustre is metallic, and more or less shining.

Though sometimes crystallized, it is usually amorphous, and has also been observed dendritic, botryoidal, &c. Its crystals, like those of the sulphuret of iron, have a cube for their primitive form; and their secondary forms are perfectly similar to those of that sulphuret.—Thus it occurs in cubes, whose edges are sometimes truncated;—in dodecaedrons with pentagonal faces;—in regular octaedrons, which are sometimes cuneiform with the terminating edges truncated (Pl. V, fig. 25.);—sometimes each solid angle of the octaedron is replaced by two faces;—also in icsaedrons.—Their forms are often very perfect, and their size sometimes considerable. Their surface has usually a splendid, metallic lustre; that of the cube is often striated.

(*Chemical characters.*) Before the blowpipe it exhales a whitish smoke, and a strong odor of arsenic, the latter of which is scarcely perceptible, when a fragment is exposed to the flame of a candle only. To borax it imparts a fine blue. A specimen from Tunaberg in Sweden yielded Klaproth cobalt 44.0, arsenic 55.5, sulphur 0.5. In another, Tassaert found cobalt 36.7, arsenic 49.0, iron 5.60, sulphur 6.5; = 97.8. In a specimen from Norway, Stromeyer found cobalt 33.1, arsenic 43.5, sulphur 20.1, iron 3.2; = 99.9.

It appears from the foregoing analyses, that this, like the preceding species, is composed chiefly of arsenic and cobalt; and it is still doubtful

whether they constitute two distinct species. They scarcely differ, except in their structure, and the degree of heat, at which they begin to exhale an arsenical odor. Future and more numerous analyses must remove the present uncertainty.

The *distinctive characters* between arsenical and Gray cobalt have already been mentioned.—The structure and chemical characters will serve to distinguish Gray cobalt from ores of other metals.

(*Geological situation and Localities.*) Gray cobalt occurs chiefly in primitive and transition rocks. It is accompanied by other ores of cobalt, and by those of nickel, arsenic, silver, copper, &c.—It is found in Germany, Norway, and other parts of Europe. The finest crystals come from Tunaberg in Sweden, where this ore exists in mica slate.

(*Uses.*) This species and arsenical cobalt are explored to furnish zaffre or smalt, which is employed to give a blue color to porcelain. (See remarks under Arsenical cobalt.)

SPECIES 3. SULPHURET OF COBALT.

Cobalt sulfuré. Lucas. Kobaltkies. Hausmann. Cobaltkies. Jameson.

This ore is whitish, or bright steel gray. Its texture is compact, and its fracture uneven, presenting metallic grains. It occurs massive, or botryoidal with a shining surface.

Before the blowpipe it exhales the odor of sulphur, and melts into a brittle, shining globule, whose fracture is a much lighter gray, than its exterior. It gives to borax a deep blue. It is composed of cobalt 43.2, sulphur 38.5, copper 14.4, iron 3.53, earths 0.33;=99.96. (*HISINGER.*)

It is found near Riddarhyttan in Sweden, with pyritous copper in gneiss.

SPECIES 4. OXIDE OF COBALT.

Cobalt oxidé noir. Haüy. Cobalt oxidé. Brongniart. Cobalt ochre. Jameson. Earthy Cobalt. Aikin. Phillips.

Its colors vary from a dull bluish or brownish black to brown or yellowish brown, and thence to a dirty straw yellow or yellowish gray. Though sometimes friable, it is usually more or less indurated, but is easily broken. Its fracture is, in general, dull and earthy, but in some varieties it becomes uneven or a little conchoidal. It has a shining streak; and, when rubbed by a hard, smooth body, it acquires a strong resinous lustre, which constitutes a character somewhat peculiar. Its specific gravity is sometimes 2.42.

(*Chemical characters.*) Before the blowpipe it gives to borax a blue more or less deep, and sometimes exhales an arsenical odor. It is an Oxide of cobalt, sometimes considerably pure, but is more frequently mixed with oxide of iron, or with arsenic. The black and yellow are considered the purest varieties.

Its chemical characters sufficiently distinguish it from black silver and the black oxide of manganese.

*Var. 1. BLACK OXIDE OF COBALT.** Its color is bluish black, which, when the mass is friable, often becomes brownish or grayish black. It is sometimes more or less indurated and compact, and sometimes friable and earthy, or even loose. It occurs amorphous, or in reniform or botryoidal masses, or in crusts, or is cellular and resembles a scoria. Its fracture is, in general, dull and earthy, but sometimes uneven or nearly conchoidal with a little lustre.

It is sometimes disseminated in quartz, or sulphate of barytes.

2. BROWN OXIDE OF COBALT.† Its color is liver brown, or yellowish brown, sometimes grayish brown. It is always amorphous, with a dull earthy fracture. It is often impure, being mixed with an ochreous oxide of iron.

3. YELLOW OXIDE OF COBALT.‡ Its color is a dull straw yellow, passing to yellowish gray. It occurs amorphous, and is sometimes corroded, or traversed by cracks. It is sometimes friable.—By friction it acquires a resinous lustre, and to borax communicates a blue color.—It is a rare variety.

(*Geological situation and Localities.*) The Oxide of cobalt seldom exists in any considerable quantity; and it occurs more frequently in secondary than primitive rocks. It often contains the arseniate of cobalt, disseminated in rose colored spots. It is also associated with the oxides of iron and nickel, with certain ores of copper and silver, and sometimes incrusts them.

It is found at Schneeberg, &c. in Saxony; Saalfeld in Thuringia, &c. At Riegelsdorf in Hessa, it occurs in scattered masses in veins, composed of quartz, sulphate of barytes, and carbonate of lime, which traverse compact limestone, sulphate of lime, and a black slate, which is sometimes bituminous, and contains copper and impressions of fish. In England, at Alderly Edge, the black variety occurs in sandstone.

The Oxide of cobalt, when sufficiently pure and abundant, is extremely valuable in the preparation of smalt.

SPECIES 5. SULPHATE OF COBALT.

Cobalt sulfaté. *Brongniart.* Red Vitriol. *Jameson. Aikin. Phillips.*

This salt has a pale rose red color, is translucent, and soluble in water.—It has been found in stalactites or crusts in the galleries of a copper mine at Hergrundt, in Hungary, &c.

* Schwarzer Erdkobalt. *Werner.* Black Cobalt ochre. *Kirwan. Jameson.* Cobalt oxidé mame-lone-terreux-vitreux. *Hauy. Brongniart.* Kobaltschwarze. *Hausmann.*

† Cobalt oxidé brun. *Brongniart.* Brauner Erdkobalt. *Werner.* Brown Cobalt ochre. *Kirwan. Jameson.* Le Cobalt terreux brun. *Brochant.* Erdkobalt. *Hausmann.*

‡ Cobalt oxidé jaune. *Brongniart.* Gelber Erdkobalt. *Werner.* Yellow Cobalt ochre. *Kirwan. Jameson.* Le Cobalt terreux jaune. *Brochant.* Erdkobalt. *Hausmann.* Cobalt oxidé ferrifere. *Lucas.*

SPECIES 6. ARSENIATE OF COBALT.

Cobalt arseniaté. *Hauy. Brongniart.* Rother Erdkobalt. *Werner.* Prismatic Red Cobalt. *Jameson.*
 Le Cobalt terreux rouge. *Brochant.* Red Cobalt ore. *Kirwan.* Red Cobalt. *Aikin. Phillips.* Kobaltbluthe. *Hausmann.*

The color of this ore is somewhat peculiar, being ordinarily a peach-blossom or violet red, though sometimes passing to crimson, or other shades of red, or even to other colors in consequence of decomposition. Its powder retains very nearly the color of the mass.—It occurs in minute or acicular crystals, or in crusts, or in small masses sometimes reniform, &c. It is less hard, than calcareous spar; and its specific gravity, according to Mohs, is between 4.0 and 4.3.

(*Chemical characters.*) Before the blowpipe it is neither melted nor volatilized; but its acid is in part disengaged, exhaling the odor of arsenic, and a dark gray or blackish oxide remains. To borax it communicates a fine blue. It contains, according to Bucholz, oxide of cobalt 39, arsenic acid 38, water 23.—In many cases, it appears to result from the decomposition of arsenical cobalt; indeed this latter mineral, when exposed to air and moisture, often exhibits a reddish efflorescence.

*Var. 1. ACICULAR ARSENIATE OF COBALT.** Its peculiar peach-blossom red sometimes passes into crimson red; and, from decomposition, may become brown or grayish. It is usually translucent, sometimes at the edges only. It has, in general, a strong external lustre, and its color is scarcely changed in the streak.—It is brittle, easily scraped by a knife, and has a low specific gravity.

It occurs in minute prisms or acicular crystals, usually short, and sometimes compressed. When distinct, they often appear to be double six-sided pyramids, or four or six-sided prisms.—These crystals are usually aggregated, and sometimes form small masses, whose fracture presents broad, diverging, or even radiated fibres; their lustre is often more or less shining and pearly. Sometimes the fibres constitute mere crusts.

2. EARTHY ARSENIATE OF COBALT.† This variety also is peach-blossom red, which sometimes inclines to crimson red, and sometimes to rose red or reddish white. It is either friable, or somewhat indurated with an earthy, dull fracture. It occurs in crusts, which are sometimes reniform or botryoidal. As it often accompanies other ores of cobalt, it frequently serves to point them out.

3. SLAGGY ARSENIATE OF COBALT.‡ This variety occurs in crusts, or smooth reniform masses, which have a conchoidal fracture, and shining resinous lustre. It easily yields to the nail, is translucent, and has a dull red or brownish color.

* Cobalt arseniaté aciculaire. *Hauy. Brongniart.* Kobaltbluthe. *Werner.* Cobalt-bloom. *Jameson.* Fleurs de Cobalt. *Brochant.*

† Cobalt arseniaté pulverulent. *Hauy. Brongniart.* Kobaltbeschlag. *Werner.* Cobalt crust. *Jameson.* Le Cobalt terreux rouge pulverulent. *Brochant.*

‡ Slaggy Red Cobalt. *Jameson.* Schlackige Kobaltbluthe. *Hausmann.*

(*Geological situation and Localities.*) Arseniate of cobalt is one of the more common ores of this metal; but has never occurred in sufficient quantities to be explored. It is found both in primitive and secondary rocks, and usually accompanies other ores of cobalt; sometimes also it is associated with ores of copper, nickel, lead, and silver, or is disseminated in their gangues. In the eastern part of Ireland, it occurs on the surface of talc slate, which forms a bed in mica slate. (*PHILLIPS.*)—The slaggy variety is found at Wittichen in Furstenburg.

In the *United States*. In *Connecticut*, at Chatham, it occurs peach-blossom red in crusts, or disseminated in feldspar. (*PIERCE & TORREY.*)

SUBSPECIES 1. ARGENTIFEROUS ARSENIATE OF COBALT.

Cobalt arseniaté terreux argentifere. *Haüy*. Cobalt Merdoie. *Brongniart*. Gänsekœthiges silber of the Germans.

It occurs in friable masses, which, however, are not easily reduced to a fine powder. Its colors are composed of green and yellow variously intermingled, or are greenish and reddish black.—It appears to be a mixture of the arseniate of cobalt with the oxides of cobalt and nickel and with an earthy gangue, containing silver. Sometimes it invests the sulphuret of silver; and sometimes capillary native silver appears on its surface.

A specimen from Allemont yielded Schreiber cobalt 43.0, arsenic 20.75, silver 12.75, water and sulphuric acid 15.25, the remainder being iron and mercury.

It is explored as an ore of silver at Mount Chalances, near Allemont; at Schemnitz in Hungary, &c.

GENUS XIV. MANGANESE.

Manganese, which is with great difficulty obtained in a metallic state, has a grayish white color with some lustre. Its texture is granular; and its hardness is nearly the same as that of iron. Its specific gravity is 8.00. It has little or no malleability.—It absorbs oxygen by exposure to the air;—and its melting point is estimated at about 160° W.

(*Uses and Remarks.*) In its metallic state Manganese is not applied to any use. Its native oxide is employed to furnish oxygen gas, and, with the assistance of muriate of soda, to prepare oxymuriatic acid for bleaching.—When added in small quantities to glass, it removes the greenish or yellowish tinge, which arises from iron or other impurities; but, in larger quantities, it communicates to glass or enamel a violet or purple color.—It also enters into the composition of certain brown colors, employed in the painting of porcelain, and is sometimes used to give a black color to the glazing of certain kinds of pottery.

The ores of Manganese present much diversity in their external characters. But all minerals, containing any considerable quantity of this metal, when melted with borax and a little nitre, yield a violet glass. Saline and earthy substances, which contain the oxide of Manganese, become brown by exposure to heat, although previously white, gray, &c. indeed some undergo this change even by the action of the air.

SPECIES 1. SULPHURET OF MANGANESE.

Manganese sulfuré. *Hauy. Brongniart. Schwarzerz. Hausmann. Sulphuret of Manganese. Jameson. Aikin. Phillips.*

Its color, on a recent fracture, is blackish gray or very dark steel gray; but by exposure it becomes brownish black. Its streak is somewhat shining, but its powder is dull greenish yellow. (*BRONGNIART.*) It is opaque. It occurs in amorphous or reniform masses. Sometimes it presents a texture more or less foliated; but more frequently it has a fine grained, or an uneven fracture, and a shining lustre somewhat metallic. It is easily scratched by a knife, which thus detaches a great number of small grains. Its specific gravity is 3.95.—The foliated variety is sometimes divisible into rhombic prisms. Indeed it is said to occur in prismatic crystals.

(*Chemical characters.*) Before the blowpipe, it is infusible, but tinges borax violet blue. When diluted nitric acid is poured on this mineral in a state of powder, sulphuretted hydrogen gas is rapidly disengaged. A specimen from Nagyag yielded Vauquelin manganese slightly oxidated 85, sulphur 15. Klaproth found a little carbonic acid, which probably proceeded from the gangue.

Sulphuret of manganese is found in the gold mines of Nagyag in Transylvania; its gangue is carbonate of manganese and quartz.—It has also been observed in Cornwall and Mexico.

SPECIES 2. OXIDE OF MANGANESE.

Gray Manganese. *Aikin. Gray Oxide of Manganese. Phillips.*

This is the only ore of manganese, which occurs in any considerable quantity. Its external characters are so various, that very little benefit can result from general expressions of these characters.

It is infusible by the blowpipe, but is converted into a brownish oxide. To borax it communicates a violet color, which varies a little, according to the degree of oxidation; thus it sometimes inclines to red, and sometimes is violet blue. Heated with sulphuric acid, it yields oxygen gas; and with muriatic acid, it exhales the odor of chlorine or oxymuriatic acid.—The manganese in this species is highly oxidated; and although sometimes it is nearly a pure oxide, several foreign substances are often present.

According to the recent experiments of Arfvedson, this mineral is sometimes in the state of a peroxide, and sometimes it contains water, being a hydrated oxide. A specimen from Undenas, in West Gothland, yielded him brown oxide of manganese 86.4, water 10.1, oxygen 3.5. The hydrated oxide, according to Arfvedson, does not soil the fingers, like the peroxide, and yields a brown or reddish brown powder.—This distinction is important to those, who prepare oxygen gas and chlorine, as the peroxide yields much more oxygen, than the hydrate. The peroxide, with the same quantity of sulphuric acid and muriate of soda, yields three times as much chlorine, as could be obtained from the hydrated oxide.

*Var. 1. RADIATED OXIDE OF MANGANESE.** Its general aspect is metallic, and very often with a strong lustre. Its color is a dark steel gray, sometimes inclining to iron black, and sometimes to silver white. Its streak and powder are dull, and nearly black. It is tender, easily scraped by a knife, and, when rubbed on paper, usually leaves a black trace.

Its structure is generally fibrous or radiated; sometimes also it is foliated,† but the surface of the folia is marked with striæ. Its specific gravity extends from 4.80 to 4.14 or even lower.

This variety is sometimes massive, and sometimes in crystals more or less distinct. The primitive form, which it sometimes presents, is a four-sided prism with rhombic bases of about 100° and 80°. This prism is often truncated on its lateral edges, and terminated by diedral or tetraedral summits. (Pl. V, fig. 26.) Sometimes the prism is short, or even tabular.—These crystals, often longitudinally striated, are very frequently acicular;—their lustre is often very high; and, when traversing small cavities in their gangue, they sometimes appear extremely beautiful.

Sometimes it is filiform or capillary, and resembles metallic threads or hairs, scattered on the surface of other minerals.

The acicular crystals are usually aggregated into masses, whose fracture is fibrous or striated, and more or less shining with a metallic lustre. The fibres, either broad or narrow, are sometimes parallel, but more frequently diverge in fascicular groups, or in stars, or are interlaced, crossing each other in all directions.—It also occurs botryoidal, reniform, &c.;—and sometimes its masses present granular distinct concretions.

A specimen yielded Klaproth oxide of manganese 99.25, water 0.25;=99.50. In another, he found oxide of manganese 92.75, water

* Strahliges and Faseriges Grau Braunsteinerz. *Werner*. Radiated and Fibrous Gray Manganese ore. *Jameson*. Manganese oxidé métalloïde. *Hauy*. Strahliger and Haarformiges Grau Braunstein. *Hausmann*.

† Blattriges Grau Braunsteinerz. *Werner*. Foliated Gray Manganese ore. *Jameson*.

7.0 ;= 99.75. In a specimen from Piedmont, Cordier found manganese 44.0, oxygen 42.0, oxide of iron 3.0, silex 5.0, carbon 1.5 ;= 95.5. It sometimes contains a little iron, silex, or carbonate of lime.

Its infusibility sufficiently distinguishes it from the sulphuret of antimony.

ARGENTINE OXIDE OF MANGANESE.* Its color is yellowish gray or yellowish white, with a lustre like that of silver. It occurs in delicate filaments, sometimes united in tufts ; or in small masses, composed of grains or scales ; or in thin layers on the surface of sparry iron or the brown hematite, or in cavities of the latter ore, &c. It is easily crumbled between the fingers.

The radiated Oxide of manganese is found chiefly in primitive rocks. Fine specimens come from France, and from the Harz ; at the latter place it occurs in large crystals in a gangue of sulphate of barytes.

2. COMPACT OXIDE OF MANGANESE.† Its colors are dark steel gray, iron or bluish black, brownish black, brown or violet brown. It sometimes scratches glass, but is, in general, easily broken, or scraped by a knife. It soils the fingers more than the preceding variety.

Its texture is compact ; and its fracture even, or a little conchoidal, and sometimes uneven. It is dull, or has a moderate metallic lustre, which is principally confined to certain points. Though its texture is compact, its masses sometimes embrace small cavities ; and its specific gravity becomes as low as 3.70.—It occurs amorphous, and is sometimes reniform, tuberos, stalactical, botryoidal, dendritic, &c.

This variety is often impure. According to the analyses of Cordier, Vauquelin, and others, it may contain from 84 to 67 parts of oxide of manganese. Sometimes 18 or 20 per cent. of iron is present ; the other ingredients are chiefly silex, carbonate of lime, magnesia, and barytes, the last of which sometimes amounts to nearly 15 per cent. and increases the hardness of the ore.—It sometimes contains copper, forming *Cupreous oxide of Manganese*.

It often resembles the brown hematitic oxide of iron ; but its compact texture, and more especially its black powder, and the violet glass, which it produces with borax, sufficiently distinguish it.

3. EARTHY OXIDE OF MANGANESE.‡ Its color varies from a very dark steel gray or iron black to bluish or brownish black, and even to brown, and reddish brown. Its texture and fracture are earthy. It is easily reduced to powder, being usually more or less friable, and

* Manganese oxidé argentin. *Haüy*.

† Dichter Grau Braunsteinerz. *Werner*. Compact Gray Manganese ore. *Jameson*. Manganese oxidé compacte, &c. *Haüy*. Manganese terne compacte. *Brongniart*. Dichter Braunstein. *Hausmann*. Compact Gray Manganese. *Aikin*. Compact Gray Oxide of Manganese. *Phillips*.

‡ Manganese oxidé pulverulent, ramuleux, &c. *Haüy*. Erdiches Grau Braunsteinerz. *Werner*. Earthy Gray Manganese ore. *Jameson*. Ochre of Manganese. *Kirwan*. Manganese terne terreux. *Brongniart*. Ochriger Braunstein. *Hausmann*. Earthy Gray Oxide of Manganese. *Phillips*.

sometimes it occurs loose. It is dull, or sometimes contains minute scaly particles, which give it a glimmering lustre. It strongly soils the fingers.—Its specific gravity is so low, being sometimes between 2 and 3, that it appears too light to contain any metallic substance.—It occurs amorphous, in crusts, dendritic, botryoidal, or tuberos, or in small globular masses loosely connected, or in a pulverulent state.

Some varieties, nearly or quite dull, and having a brown earthy aspect, sometimes exhibit more or less of a fibrous texture.

It sometimes contains a large quantity of iron. In a specimen from Devonshire, Mr. Wedgewood found oxide of manganese 43, oxide of iron 43. In another from the Harz, Klaproth found oxide of manganese 68.0, water 17.5, silex 8.0, oxide of iron 6.5, carbon 1, barytes 1;=102.

In the Cevennes, this variety occurs in granite; it is extremely light and friable, and divides into irregular prisms.

The earthy manganese, especially that of Devonshire, is often called *Wad*. It is generally blackish or reddish brown, very light, and strongly soils the fingers. When dry, and moderately heated with one fourth its weight of linseed oil, it inflames.

(*Geological situation.*) The Oxide of manganese, though sometimes in secondary rocks, is most frequently found in primitive or transition mountains. It occurs in nodules or irregular masses, in veins, and in beds. The radiated variety is more particularly confined to primitive rocks; but the three varieties are often connected with each other. It frequently accompanies the brown oxide of iron;—and in secondary rocks is most common in compact limestone.

But, though mines of this ore may be somewhat uncommon, there is scarcely any metal, iron excepted, more *extensively* diffused, than Manganese in the state of an Oxide. It enters into the composition of many minerals, and often performs the part of a coloring matter. Limestones, which contain this Oxide, become brown by exposure to the action of heat; and the lime, which they furnish, possesses the valuable property of forming a hard mortar under water.

This Oxide often appears in thin crusts, or in black dendrites, on compact limestone and various other minerals, stony, saline, and metallic. It exists even in the vegetable kingdom, and hence appears in the ashes of certain vegetables.

The Oxide of manganese is often associated with sulphate of barytes, and frequently contains the base of this salt. It exists in variable proportions in the garnet, schorl, epidote, augite, &c. &c.—also in several ores of iron, especially the brown oxide and sparry iron.

(*Localities.*) This Oxide is found in France, England, Germany, and various other parts of Europe.

In New Brunswick, at Quacow, about 30 miles from St. John; it is of good quality;—also in Nova Scotia, at Newport, and Cape Dore. (*THAYER.*)

In the *United States*. In *Arkansas Territory*, Lawrence County; it soils the fingers, and is associated with ores of iron. (*SCHOOLCRAFT.*)—In *Missouri*, near the head of Merrimack river, 40 miles from Potosi, with ores of iron. (*SCHOOLCRAFT.*)—In *Kentucky*, near Greensburg;—also near Big Sandy river.—In *Virginia*, Shenandoah County, sometimes crystallized, but usually compact. (*HARDEN.*)—Also in Albermarle County.—In *Maryland*, near Baltimore, in small quantities.—In *Pennsylvania*, Luzerne County, near Wilkesbarre, both crystallized and amorphous. (*WISTER.*)—Also near Lancaster;—and in Northumberland County;—also on the east branch of the Susquehanna, near where it enters the State.—In *New Jersey*, near Hamburg. (*GIBBS.*)—In *New York*, near Ancram.—Also on the island of New York, in hollow, friable pebbles in alluvial hills, and is very pure. (*PIERCE & TORREY.*)—Also near Troy.—In *Vermont*, at Monkton, it occurs both crystallized and earthy, in connexion with brown hematite. (*GIBBS.*)—Also at Bennington, it is compact or earthy, sometimes slightly mammillary, brown or brownish black, and associated with brown hematite. (*HALL.*)—In *Connecticut*, at Lebanon, in small quantities.—In *Massachusetts*, at Milton and Lynn; it occurs dendritic or in mammillary incrustations on compact feldspar and sienite. (*J. F. & S. L. DANA.*)—Also at Leverett, in small masses, much resembling granular oxide of iron, in alluvial soil—also at Deerfield. (*HITCHCOCK.*)—Also near Great Barrington in gneiss. (*EATON.*)—In *Maine*, at Thomastown, it occurs compact in limestone.

(*Uses.*) This Oxide is employed, in small quantities, to remove color from glass; and, in larger quantities, to communicate a violet blue color. It is also employed in porcelain painting—in glazing common pottery—and in the preparation of oxygen gas and chlorine.

SUBSPECIES 1. FERRUGINOUS OXIDE OF MANGANESE.

Schwarz Eisenstein. *Werner*. Black Manganese ore. *Jameson*. La Mine de fer noir. *Brochant*. Schwarz Braunstein. *Hausmann*. Black iron ore. *Aikin*. *Phillips*.

This mineral is by some arranged among the ores of iron, and is indeed said to be sometimes smelted as such. Hence we have distinguished it by the epithet *ferruginous*, although other varieties of the Oxide of manganese are known to contain large quantities of the oxide of iron.—It has not been analyzed; but, like the preceding varieties of the Oxide of manganese, it yields with borax a violet glass, and its external characters resemble those of this Oxide.

Its color is nearly bluish black, or dark steel gray. It occurs amorphous, reniform, botryoidal, tuberos, &c. Its structure some-

times exhibits very delicate diverging fibres; but more frequently its fracture is conchoidal or uneven. The compact variety is sometimes composed of curved lamellar concretions. Its lustre is feeble, and scarcely metallic; but its streak is shining. It yields with some difficulty to the knife, but does not strike fire with steel. Its specific gravity is sometimes 4.75.

It has also been observed in opaque masses with a *foliated* structure, and considerable lustre.

With borax it melts easily, and gives a violet blue glass. It yields good iron, but acts strongly on the sides of the furnace. (*JAMESON.*)

It occurs both in primitive and secondary rocks, and is usually associated with sparry iron, and the brown oxide of iron.

It is found in Thuringia, Westphalia, &c.

The *Knebelite* is probably a variety of this Oxide.

SPECIES 3. SILICEOUS OXIDE OF MANGANESE.

Variety of Manganese lithoide. *Brongniart.* Rother Braunstein. *Werner.* Rhomboidal Red Manganese. *Jameson.* Siliceiferous Oxide of Manganese. *Phillips.* White Manganese. *Aikin.* Rothstein. *Hausmann.*

Its colors are reddish white, rose red, reddish or yellowish brown, and sometimes blackish brown. It is slightly translucent, especially at the edges. It is harder than calcareous spar, and often scratches glass. Its specific gravity is between 3.2 and 3.6.

It is sometimes in masses, composed of granular concretions, with a foliated structure, and a glistening lustre.—It also presents compact masses, whose fracture is even or conchoidal, sometimes splintery, and nearly dull.—It is sometimes in an earthy state.

(*Chemical characters.*) Before the blowpipe, it becomes blackish; but is scarcely fusible. A specimen from Langbanshytta yielded Berzelius oxide of manganese 52.6, silex 39.6, oxide of iron 4.6, lime 1.5, volatile matter 2.75;=101.05. In another from Siberia, Lampadius found oxide of manganese 61, silex 30, oxide of iron 5, alumine 2;=98.

(*Localities.*) In Sweden, at Langbanshytta, it is connected with magnetic oxide of iron, garnet, &c. in gneiss.—At Kapnic, in Transylvania, it is associated with sulphuret of manganese, &c.—In Devonshire, near Tavistock, it occurs with the gray oxide of manganese, and contains in its cavities crystals of quartz.

SPECIES 4. CARBONATE OF MANGANESE.

Manganese oxidé carbonaté. *Hauy.* Variety of Manganese lithoide. *Brongniart.* Carbonated oxide of Manganese. *Phillips.*

The general aspect of this ore is stony, and much resembles that of the siliceous oxide of manganese. Its colors are white, rose red, and sometimes brownish,—the shade of brown probably proceeding from

exposure to the air. It is slightly translucent; yields to the knife, and scarcely scratches glass. Its specific gravity is about 3.23.

It occurs amorphous, or in concretions, which are sometimes globular or reniform. Its structure is foliated, and its fracture splintery.—It is said to occur in rhombs and lenticular crystals.

(*Chemical characters.*) When exposed to heat, all its colors are brown. It is not melted by the blowpipe, but it gives to borax a violet color, which has often a strong shade of red. A specimen from Transylvania yielded Lampadius manganese slightly oxidated 48.0, carbonic acid 49.0, oxide of iron 2.1, siliceous 0.9. In a brown specimen from Bohemia, Descotils found oxide of manganese 53.0, carbonic acid and water 35.6, oxide of iron 8.0, lime 2.4, siliceous and arsenical iron 4.

(*Localities.*) The white and red varieties have been found chiefly in the mines of Kapnic and Nagyag in Transylvania. They occur in veins and constitute a part of the gangue of native auriferous tellurium; are accompanied by gray copper, the sulphurets of lead, antimony, &c.—The brown variety is found in Bohemia, and much resembles sparry iron.

SPECIES 5. PHOSPHATE OF MANGANESE. JAMESON.

Manganese phosphaté. Brongniart. Manganese phosphaté ferrifère. Haüy. Eisen Pecherz. Werner.
Fer phosphaté. Brochant. Triplit. Hausmann. Phosphate of Manganese. Aikin. Phillips.

In the purer varieties its color is brown, reddish brown, or brownish red; but it sometimes passes to blackish brown or black. Its powder also is brown, or reddish brown. It is nearly or quite opaque, unless in thin fragments. It slightly scratches glass, but is easily broken and reduced to powder.

It occurs in masses, whose fracture is imperfectly conchoidal, or uneven, and sometimes even; it is either dull, or has a resinous lustre. Its structure is imperfectly foliated; and mechanical division indicates a rectangular prism with square bases for the primitive form. Its specific gravity is between 3.40 and 3.95.

(*Chemical characters.*) Before the blowpipe it melts into a black enamel;—and is soluble in nitric acid without effervescence. When brownish red, it appears to be nearly a pure phosphate; but a specimen, analyzed by Vauquelin, yielded oxide of manganese 42, phosphoric acid 27, oxide of iron 31. According to Berzelius, it contains oxide of manganese 32.60, phosphoric acid 32.78, oxide of iron 31.70, phosphate of lime 3.20; = 100.28.

This ore has been found chiefly at Limoges in France, in a vein of quartz, containing the beryl, and traversing granite.—It is said also to occur in Pennsylvania.

GENUS XV. *ARSENIC.*

Metallic Arsenic is remarkably brittle, and indeed almost friable, being easily broken by a slight blow, and reducible in a mortar to a fine powder. Its hardness is moderate; and its specific gravity is about 5.76. Its texture is more or less foliated, and sometimes striated. The color of its fresh fracture is bluish gray, with considerable lustre.

But, when exposed to the air, it soon absorbs oxygen, loses its lustre, and eventually becomes black; indeed it sometimes falls to powder. Its volatility is so great, that, even before it melts, it sublimes in the state of an oxide, forming a white vapor or smoke, which exhales a strong and peculiar odor, much resembling that of *garlic*. By increasing the heat, it burns with a bluish flame.

(*Uses and Remarks.*) Arsenic in its metallic state enters into the composition of certain alloys. Its oxide is employed in the manufacture of glass, in dying, and the preparation of certain pigments. It is sometimes used in medicine; but, when in the state of an oxide, it forms the most violent of mineral poisons.

The existence of the oxide of Arsenic in solution may, in general, be satisfactorily ascertained, by *successively* adding small quantities of a solution of carbonate of potash and of sulphate of copper to the *suspected* fluid, both solutions being warm. If Arsenic be present, the fluid assumes a lively grass green color.

Arsenic is obtained in the state of an oxide during the roasting of certain ores, particularly those of cobalt. In this process, the oxide is sublimed, and condensed in long flues, connected with the furnace. Much of it is thus obtained in Saxony and Bohemia.

Arsenic, in whatever state it exists, may be recognised by the peculiar odor of garlic, which it exhales, when exposed to a proper degree of heat, on charcoal. An odor somewhat similar is indeed exhaled by the oxide of antimony; but it is much less striking, and easily distinguished after a few experiments. Antimony is less volatile than Arsenic, and melts before it is volatilized.

SPECIES 1. NATIVE ARSENIC. KIRWAN. JAMESON.

Gediegen Arsenik. Werner. Hausmann. Arsenic natif. Haüy. Brochant. Brongniart. Native Arsenic. Aikin. Phillips.

In most of its characters it resembles purified arsenic. The color of its recent fracture is steel gray or nearly tin white; but it soon tarnishes, and eventually becomes grayish black with a diminished lustre. It is not very easily scratched by a knife, and its streak has a shining metallic lustre; but its powder is dull and black. It yields to the knife, and is very easily broken, but less so than purified arsenic. Its specific gravity usually lies between 5.30 and 5.80.—When struck or rubbed by a hard body, it exhales the odor of garlic.

It occurs in amorphous masses, or in reniform, botryoidal, or mammillary concretions, or in plates, &c. Its fracture is uneven, or even, or imperfectly foliated with curved layers, and sometimes it presents diverging fibres. Its lustre is metallic, but moderate.—Its masses sometimes exhibit cubic or octaedral impressions.

(*Chemical characters.*) When exposed to heat on charcoal, it burns with a blue flame, yielding a dense, white vapor, which has the odor of garlic, and a coat of white oxide of arsenic remains on the coal. It is seldom perfectly pure. It sometimes contains a little silver or gold, and very often a little iron, which remains as a scoria, when the arsenic is volatilized.

Var. 1. CONCRETED NATIVE ARSENIC.* It usually occurs in reniform, tuberos, botryoidal, or stalactical concretions, which are composed of curved and concentric layers. Sometimes the concretion embraces a nucleus of sulphuretted antimonial silver.

2. SPECULAR NATIVE ARSENIC.† This very remarkable variety of arsenic possesses a metallic brilliancy, and exists in thin layers, attached to the surface of other minerals.—Before the blowpipe it exhales white fumes with the odor of garlic; it leaves no metallic globule, nor does it, like arsenical cobalt, give a blue color to borax.

It has been found at Annaberg in Bohemia. It is always attached to the surface of those minerals, which are contiguous to the walls of the vein. It has been suggested, that its lustre may arise from friction.

3. AMORPHOUS NATIVE ARSENIC.‡ It occurs in amorphous masses, whose texture may be fibrous, compact, or earthy. Its fracture often presents a great number of minute glistening scales. It is sometimes very friable.

(*Geological situation and Localities.*) Native arsenic belongs chiefly to primitive rocks. But, instead of forming veins by itself, it usually accompanies other ores, particularly those of silver, cobalt, nickel, &c. Thus it is associated with the sulphuret of silver, sulphuretted antimonial silver, arsenical and gray cobalt, arsenical nickel, gray copper, sparry iron, &c.

It is not a very rare mineral; and is found in several mines of Saxony, Bohemia, France, England, Norway, &c.—In Siberia, in the silver mine of Zmeof, it occurs in large masses.

In the *United States*, it is said to occur at Gayhead, on Martha's Vineyard.

* Arsenic natif concretionné. *Brongniart.* Arsenic tuberculeux testacé. *Hauy.*

† Arsenic natif speculaire. *Brongniart.*

‡ Arsenic natif amorphe. *Hauy.* *Brongniart.*

SPECIES 2. SULPHURET OF ARSENIC. PHILLIPS.

Arsenic sulfuré. *Hauy. Brongniart.* Rauschgelb. *Werner.* Le Realgar. *Brochant.* Realgar. *Aikin.*
 Arsenikblende. *Hausmann.*

This ore, as its name indicates, is composed of Arsenic and Sulphur. Hence before the blowpipe it burns, is volatilized, and exhales the odor *both* of arsenic and sulphur. Its colors are *red* or *yellow*, depending probably on different proportions of the ingredients.—Two subspecies have been established on this distinction of color.

SUBSPECIES 1. REALGAR. KIRWAN.

Arsenic sulfuré rouge. *Hauy.* Arsenic sulfuré Realgar. *Brongniart.* Roth's Rauschgelb. *Werner.*
 Red Orpiment. *Jameson.* Le Realgar rouge. *Brochant.* Realgar. *Hausmann. Phillips.*

Red Sulphuret of Arsenic.

Its color is a lively red, often more or less tinged with yellow, being most frequently an aurora or a scarlet red, and sometimes nearly blood red. Both its streak and powder are orange yellow. It is sometimes opaque, often translucent, and its crystals are semitransparent.

It is so soft and tender, that it may be scratched by the finger nail. Its fracture is uneven or conchoidal, and more or less shining with a vitreous lustre. It acquires negative electricity by friction, even when not insulated;—and its specific gravity is about 3.30.

It occurs in regular crystals, in compact masses, in concretions, in flakes, or in crusts, which are sometimes earthy.

The primitive form of its crystals is an oblique four-sided prism with rhombic bases of $107^{\circ} 42'$ and $72^{\circ} 18'$. Its secondary forms are also prisms, having sometimes 6, 8, or even 12 sides. It has been observed under the primitive form, which is sometimes terminated by pyramids, whose faces correspond to the lateral planes. This prism is subject to truncation and bevelment on its lateral edges, and sometimes becomes an eight-sided prism. (Pl. V, fig. 27.)—Sometimes the solid angles are truncated.—The prisms with 8 and 10 sides are sometimes terminated by 5 faces at each extremity.—These crystals are usually small; their surface is longitudinally striated, and has a strong lustre.

(*Chemical characters.*) It melts easily, burns with a bluish flame, and is volatilized by the blowpipe, exhaling white fumes of arsenic, and the odor of arsenic and sulphur. In nitric acid its color disappears. It is composed, according to Thenard, of arsenic 75, sulphur 25. Klaproth found arsenic 69, sulphur 31.

(*Distinctive characters.*) The color of its powder distinguishes it from sulphuret of mercury and red silver, both of which have a *red* powder, and the latter of which is reducible by the blowpipe to a globule of silver.—In color it resembles the chromate of lead; but the chromate is about twice as heavy, and tinges borax green.

(*Geological situation and Localities.*) Realgar occurs more frequently in primitive, than in secondary rocks. It is disseminated in other minerals, or exists in metallic veins, and sometimes appears as a crust or efflorescence in those veins, which contain native arsenic. It is also associated with red silver, the sulphurets of lead and antimony, gray copper, &c.

It is found in the mines of Saxony, Bohemia, Hungary, &c. At St. Gothard, it is disseminated in dolomite;—and on the North West coast of America, it is mixed with orpiment.

Realgar is not unfrequently sublimed by volcanic fire, and is found in the fissures of lava, and near the craters of volcanoes. It thus occurs at the Solfaterra, near Naples;—at Etna, &c.—At Vesuvius, it is crystallized in the current of lava, which flowed in 1794.—At Guadaloupe, it is called *red sulphur*.

(*Uses.*) It is sometimes employed as a pigment. In China, it is formed into pagods, and into vessels for medical purposes. In these vessels, some vegetable acid is permitted to remain for a certain time, and is then used as a remedy in disease.

SUBSPECIES 2. ORPIMENT. *KIRWAN.*

Arsenic sulfuré jaune. *Hauy.* Arsenic sulfuré Orpiment. *Brongniart.* Gelbes Rauschgelb. *Werner.* Yellow Orpiment. *Jameson.* Le Realgar jaune. *Brochant.* Rauschgelb. *Hausmann.* Orpiment. *Aikin.* *Phillips.*

Yellow Sulphuret of Arsenic.

Its color is usually a lemon yellow, which is often shining and very beautiful; indeed the surface of its laminæ sometimes reflects the gilded yellow of gold—sometimes also it is sulphur or orange yellow. Its streak and powder have the same color as the mass. It is opaque, or translucent, sometimes at the edges only.

Its structure is foliated, with laminæ large or small, and often curved. The laminæ usually separate with ease, like those of mica, and are translucent, or even transparent; they are flexible, but very soft and tender. Its fracture, which of course is foliated in one direction, has, when recently made, a strong lustre, sometimes waxy, or adamantine, and sometimes nearly metallic. When its folia are small, its masses are composed of granular distinct concretions.—By friction it acquires negative electricity without being insulated;—and its specific gravity varies from 3.52 to 3.04.

It occurs in laminated or lamellar masses—in crusts—in stalactical or reniform concretions—and sometimes in minute crystals, whose forms it is not easy to determine.

(*Chemical characters.*) It is principally volatilized before the blowpipe with a white smoke, and with the odor of both sulphur and arsenic; a small, earthy residue usually remains. It melts somewhat

less easily than realgar, and, on cooling, assumes an orange tinge. According to Thenard, it is composed of arsenic 57, sulphur 43. The result of Klaproth's analysis is arsenic 52, sulphur 38.

Different opinions have existed in regard to the real difference between the *red* and *yellow* sulphurets of arsenic. But, according to the experiments of Proust and Thenard, the arsenic is, in both cases, in a metallic state, though combined with the sulphur in different proportions. Hence realgar, melted with sulphur, produces Orpiment;—and Orpiment, combined with an additional quantity of arsenic, is converted into realgar.

(*Distinctive characters.*) The foliated structure of Orpiment, and its arsenical odor, when exposed to heat, distinguish it from native sulphur.—Indeed the chemical characters of Orpiment sufficiently distinguish it from all other *yellow* minerals.

(*Geological situation and Localities.*) Orpiment is more frequently found in secondary, than in primitive rocks.—It occurs in Hungary, Natio-
lia, India, &c. In Transylvania, it is sometimes in globules, grouped like the oolite. On the North West coast of America, it is mixed with realgar.

(*Uses.*) Orpiment is employed as a pigment, but is, in general, artificially prepared. It comes chiefly from the Levant.—The Sulphuret of arsenic, though poisonous, is much less active, than the oxide of that metal.

SPECIES 3. OXIDE OF ARSENIC. JAMESON.

Arsenic oxidé. *Hauy. Brongniart.* L'Arsenic oxidé natif. *Brochant.* Native calx of arsenic. *Kirwan.*
Arsenikbluthe. *Hausmann.* Oxide of Arsenic. *Phillips.*

Its proper color is white, but it is often tinged with gray, yellow, red, green, &c. It is opaque, or, when crystallized, more or less translucent. It has an acrid taste; and its specific gravity is 3.70.

It is sometimes crystallized in quadrangular prisms or tables, or in octaedrons, or appears in groups of acicular crystals, parallel, diverging, or interlaced. These crystals or fibres are sometimes so minute and delicate, that they resemble a fine mould with a silken lustre. Its masses are sometimes partly fibrous, and partly granular.—Sometimes also it is friable and earthy, forming an efflorescence or crust—and sometimes it is more indurated, its form being tuberous, botryoidal &c. Its fracture is earthy and dull, or sometimes uneven with a moderate lustre.

(*Chemical characters.*) This Oxide is very nearly pure. It is soluble in about 80 times its weight of water at 60°. Before the blowpipe it is entirely volatilized in a white smoke with a strong odor of arsenic. It is blackened by the action of combustibles.

Its solubility in water distinguishes it from the arseniate of lime, and, in connexion with its other chemical characters, may serve to distinguish it from all other minerals, which it resembles.

(*Geological situation and Localities.*) It is usually associated with native arsenic, or with ores of cobalt, or silver. The earthy efflorescences are sometimes in metallic veins, and sometimes in the fissures of volcanic mountains, having been sublimed by the action of subterraneous fires.—It has been found at Andreasberg in the Harz;—in Hessa;—in Hungary;—and at Joachimsthal in Bohemia, where it occurs in quadrangular prisms on sulphate of barytes.

(*Remarks.*) This white Oxide is the substance usually known in commerce by the name of Arsenic; but that is artificially obtained during the roasting of certain ores of cobalt, &c.—When we consider the solubility of this Oxide in water, and its fatal action on the stomach of animals, we must recognise the goodness of the Creator in rendering it a very rare mineral.

GENUS XVI. BISMUTH.

Pure Bismuth is yellowish white with a strong lustre; indeed a very slight tinge of red or violet is also perceptible, especially after exposure to the air, by which its lustre is tarnished. Its structure is foliated with broad laminæ, which are sometimes obviously parallel to the sides of an octaedron. Its hardness differs but little from that of silver. Its specific gravity is 9.82.—It is neither ductile nor malleable, although, when cautiously hammered, it flattens a little before it breaks. It is easily crystallized in octaedrons, which are sometimes modified.

Bismuth melts at about 476° Fahr. and, of course, when in small fragments, may be fused by the flame of a candle. It is soluble in nitric acid, and the solution is decomposed by the addition of water, yielding a white precipitate of the sub-nitrate of bismuth. It is scarcely oxidated by air or water at common temperatures.

(*Uses.*) Bismuth in its metallic state is employed in the composition of pewter, soft solder, printers' types, &c. and is sometimes added to lead to increase its hardness.—Its oxide renders glass more fusible; and, if added in large quantities, it gives a yellowish tinge. The white oxide, or rather the sub-nitrate, is employed in medicine with success, as an antispasmodic, &c.

Nearly all the Bismuth of commerce is obtained from Saxony.

SPECIES 1. NATIVE BISMUTH. KIRWAN.

Bismuth natif. Hauy. Brochant. Brongniart. Gediengen Wismuth. Werner. Hausmann. Octahedral Bismuth. Jameson. Native Bismuth. Aikin. Phillips.

Native bismuth has a foliated structure, and possesses, in fact, all the essential characters of the purified metal. Its color is nearly silver white with a slight tinge of red; and its surface is sometimes irised. It yields with ease to the knife; and its specific gravity varies from 9.57 to 9.02.

It is sometimes crystallized in octaedrons, rhombs, cubes, &c.—sometimes it is in plates or leaves, whose surface often exhibits plumous striæ;—sometimes it is branched, reticulated, or dendritic;—and sometimes it occurs in lamellar masses.—Its laminae have a strong metallic lustre.

In some cases, this metal is so disseminated in its gangue, that it is invisible to the eye; but its great specific gravity and a slight greenish efflorescence may often indicate its existence, and, if the specimen be exposed to heat, the Bismuth exudes, and appears in little globules, attached to the surface.

(*Chemical characters.*) Its chemical characters are those of pure bismuth, like which it is fusible in the flame of a candle. Before the blowpipe it yields a white metallic globule, which, by urging the heat, is volatilized in the state of a yellowish white oxide. Native bismuth is seldom perfectly pure, but usually contains a little arsenic, or cobalt, and sometimes sulphur. Hence it may exhale the odor of arsenic, when heated.

Its want of malleability distinguishes it from native silver.

(*Geological situation.*) Native bismuth has been found almost exclusively in primitive rocks, more particularly gneiss and mica slate. It seldom constitutes the principal mass of the vein, but is mingled with ores of cobalt, arsenic, silver, &c. Hence it is accompanied by arsenical and gray cobalt, arsenical nickel, native silver, and the sulphurets of lead, zinc, &c. Its gangues are quartz, jasper, carbonate of lime, and sulphate of barytes.—Its leaves, plates, and dendrites are either disseminated in the gangue, or attached to its surface.

(*Localities.*) Native bismuth, which is the only ore of this metal ever explored, is still a rare mineral. It has been found more frequently in Saxony and Bohemia, than in other parts of Europe. At Schneeberg, it occurs in large irised plates, and in dendrites; the latter are in a gangue of jasper, and add much to its beauty, when polished.

In the *United States*, in *Connecticut*, at Huntington, Native bismuth is disseminated in a vein of quartz in brilliant plates or small lamellar masses seldom more than an inch in diameter; its surface is sometimes reticulated. It is associated with native silver, the sulphurets of iron and lead, pyritous copper, tungsten, and tellurium. (*SILLIMAN.*)—It is said also to have been observed in small quantities in *Indiana* and *Ohio*.

SPECIES 2. SULPHURET OF BISMUTH. PHILLIPS.

Bismuth sulfuré. *Haüy. Brongniart.* Wismuth Glanz. *Werner. Hausmann.* Prismatic Bismuth Glance. *Jameson.* Sulphuretted Bismuth. *Aikin.*

This species is not easily recognised by its external characters.

Its color is light lead gray, often tarnished with a tinge of yellow, and sometimes irised. It is brittle, very easily scraped by a knife, and sometimes soils a little. Its powder is black and glistening. (*KIRWAN.*) Its specific gravity lies between 6.46 and 6.10.

Its structure is sometimes foliated, like that of sulphuret of lead, and sometimes striated or fibrous, like that of sulphuret of antimony. Its fracture has a metallic lustre more or less shining.

It occurs massive, or in acicular crystals, and possesses natural joints, parallel to the sides and shorter diagonal of a rhombic prism.

(*Chemical characters.*) It is easily fusible even by the flame of a candle. Before the blowpipe it melts, yielding a blue flame and the odor of sulphur. It is with great difficulty reduced; but, by continuing the heat, much of it is volatilized. It does not effervesce in cold nitric acid.—It is composed of bismuth 60, sulphur 40. (*SAGE.*) It sometimes contains a little cobalt, or some other metal.

(*Distinctive characters.*) From native bismuth this ore is distinguished by its want of effervescence in cold nitric acid;—and from sulphuret of lead it differs by the same character and by its greater fusibility.—It is less volatile before the blowpipe, than sulphuret of antimony, and does not, like that sulphuret, so rapidly and entirely disappear, when fused on charcoal. Its specific gravity is also greater, than that of sulphuret of antimony.

(*Geological situation and Localities.*) The Sulphuret of bismuth is a rare ore, and occurs in veins, where it is associated with native bismuth, sparry and arsenical iron, pyritous copper, &c. Its gangue is usually quartz.—It has been found at Schneeberg in Saxony—in Bohemia—in Sweden, &c.—In Hessa, it occurs in delicate, irised needles in a mine of sparry iron.

SUBSPECIES 1. CUPREOUS SULPHURET OF BISMUTH.

Cupreous Bismuth. *Jameson.* Kupferwismuthierz. *Hausmann.* Bismuth sulfuré cuprifere. *Lucas.*
Cupriferous Sulphuretted Bismuth. *Aikin.* *Phillips.*

Its color is lead gray, varying to steel gray and tin white, and is often tarnished with shades of yellow, red, &c. It occurs amorphous, with a fine grained uneven fracture, and a shining metallic lustre. It also appears in acicular, aggregated prisms.

It contains, according to Klaproth, bismuth 47.2, sulphur 12.6, copper 34.6;=94.4.—This ore is by some considered a compound Sulphuret of bismuth and copper.

It is found near Wittichen, in Furstenburg, in veins traversing granite, with native bismuth, pyritous copper, &c.

SUBSPECIES 2. PLUMBO-CUPREOUS SULPHURET OF BISMUTH.

Bismuth sulfuré plumbo-cuprifere. *Hauy.* Acicular Bismuth Glance. *Jameson.* Nadelierz. *Werner.*
Hausmann. Plumbo-cupriferous Sulphuretted Bismuth. *Aikin.* *Phillips.*

Its color is nearly steel gray, which readily assumes a yellowish tarnish. It is amorphous, or occurs in *acicular* prisms, having four or six sides, longitudinally striated. These needles are sometimes delicate, curved, and interlaced; and are often invested with a yellowish or greenish crust, which appears to be an oxide of bismuth.

Its structure is foliated; its cross fracture uneven or a little conchoidal; and its lustre more or less shining and metallic. It yields easily to the knife; and its specific gravity is 6.15.

(*Chemical characters.*) It melts by the blowpipe into a steel gray globule; by continuing the heat, it is in part volatilized, and deposits on the charcoal a yellowish powder; a red globule, inclosing a grain of metallic lead, remains. It effervesces in nitric acid. It contains bismuth 43.2, sulphur 11.58, lead 24.32, copper 12.10, nickel 1.58, tellurium 1.32; =94.1. (JOHN.)

It is found in a gold mine near Beresof in Catharinenberg, in Siberia. Its gangue is quartz, containing also native gold, sulphuret of lead, &c.

SPECIES 3. OXIDE OF BISMUTH.

Bismuth oxidé. Haüy. Brongniart. Wismuth ocker. Werner. Hausmann. Bismuth ochre. Jameson. Aikin. Phillips.

Its color varies from greenish yellow to straw yellow, and sometimes passes to yellowish gray or gray, in consequence of impurities. It occurs in the form of a powder, or in small masses, either friable, or having the hardness of chalk, with an uneven or earthy fracture, nearly or quite dull. Its specific gravity is about 4.37.

It is soluble in nitric acid;—and on charcoal is easily reduced to metallic bismuth, which forms its most important character. A specimen, analyzed by Lampadius, yielded oxide of bismuth 86.3, oxide of iron 5.2, carbonic acid 4.1, water 3.4; =99.

Its yellow color may serve to distinguish it from the oxide of nickel, and certain ores of copper.

This Oxide is rare, and occurs in veins, which contain native bismuth, on the surface of which it sometimes appears in the form of an efflorescence.

GENUS XVII. ANTIMONY.

The color of pure Antimony is white with a slight tinge both of gray and blue. Its lustre is shining and metallic, but is diminished by exposure to the air. Its structure is foliated, and the laminæ are often found to be parallel to the sides of an octaedron, and to those of a dodecadron with rhombic faces. It is neither ductile, nor malleable. Its hardness is nearly the same as that of tin; but it is easily reduced to powder. Its specific gravity is 6.71.

Antimony is not oxidated by air or water at common temperatures. It melts at about 810° Fahr. and, by increasing the heat, it is volatilized in the form of a whitish smoke, which is an oxide of Antimony. It is easily oxidated by nitric acid, and in part dissolved.

(*Uses.*) The uses of Antimony are numerous and important. It enters into the composition of several metallic alloys, and often very

considerably increases their hardness. United with lead, it forms the alloy, of which printers' types are composed; the proportion of Antimony may vary from 15 to 25 per cent. It is an important circumstance in casting types, that this alloy expands by cooling.—Its oxides are employed in the preparation of yellow colors for painting on porcelain and enamel.—In fine, this metal, in the state of an oxide or a salt, furnishes a considerable number of important medical preparations.

SPECIES 1. NATIVE ANTIMONY. KIRWAN.

Antimoine natif, Haüy. Brongniart. Brochant. Gediegen Spiesglaz. Werner. Dodecahedral Antimony. Jameson. Gediegen Spiesglanz. Hausmann. Native Antimony. Aikin. Phillips

Its characters strongly resemble those of purified antimony. Its color is tin white, with a splendid metallic lustre, which, by exposure, becomes tarnished with shades of blackish gray or yellow. It occurs in reniform or amorphous masses, with a lamellar structure; and is divisible parallel to the sides of a regular octaedron, and dodecaedron with rhombic faces. Indeed, according to Jameson, it has been found in octaedrons and dodecaedrons. The lamellæ are sometimes slightly curved. It yields to the knife; and its specific gravity is between 6.5 and 6.8.

Before the blowpipe it easily yields a metallic globule, and exhales a white smoke, which has a faint and peculiar odor. When the globule cools slowly, it becomes covered with brilliant acicular crystals. It is very nearly pure. A specimen from the Harz yielded Klaproth antimony 98, silver 1, iron 0.25.

(*Distinctive characters.*) This ore may somewhat resemble the sulphuret of antimony, arsenical iron, and antimonial silver. But the first, when melted, exhales the odor of sulphur—the second has an uneven fracture and gives fire with steel—and the third yields a globule of silver before the blowpipe.—From native bismuth it differs in color, and in not being in any degree flattened under the hammer.

(*Geological situation and Localities.*) Native antimony is a rare ore, and is found in veins with the sulphuret and other ores of antimony, &c. At Sahlberg in Sweden, its gangue is calcareous spar.—At Andreasberg in the Harz, its gangues are quartz and calcareous spar, and it is associated with sulphuretted antimonial silver.—At Allemont, near Grenoble, it is often invested with a crust of oxide of antimony.—At Chalanches in Dauphiny, it occurs in veins, which traverse gneiss, and is associated with ores of antimony and cobalt.

In the *United States*, in *Connecticut*, at Harwinton, Native antimony in broad plates is associated with the sulphuret of antimony. (*SILLIMAN.*)

SUBSPECIES 1. ARSENICAL NATIVE ANTIMONY.*Antimoine natif arsenifere. Haüy. Brongniart.*

It is sometimes in crusts, whose surface is slightly undulated. The folia, which it presents, are smaller and more shining, than those of pure antimony. Its fracture is conchoidal.

When struck with a hammer, or heated by the blowpipe, it exhales a white smoke, which has a strong odor of garlic.—The arsenic is sometimes in the proportion of 16 per cent.

It has been found at Allemont, near Grenoble.

SPECIES 2. SULPHURET OF ANTIMONY.

Antimoine sulfuré. Haüy. Brongniart. Grau Spiesglaserz. Werner. Gray Antimony. Jameson. Aikin. Phillips. L'Antimoine gris. Brochant. Sulphurated Antimony. Kirwan. Grauspiesglanzerz. Hausmann.

The more common aspect of this ore is that of shining, metallic needles, collected into masses. Its color is lead gray, approaching more or less to steel gray. It is liable to a tarnish, which may be azure blue, pavonine, irised, &c. It is opaque, easily scraped by a knife, and so brittle, that small fragments may often be broken by the pressure of the finger. Its specific gravity varies from 4.00 to 4.60. Its powder is dull and black or grayish black, soils the fingers, and, when rubbed on paper, leaves a black trace.

This mineral occurs in regular crystals, in foliated, radiated, or granular masses, and is sometimes compact.

Its crystals are often four-sided prisms, nearly rectangular, terminated by four-sided pyramids, whose faces correspond to the lateral planes.—Sometimes two opposite lateral edges of the prism are truncated. (Pl. V, fig. 28.)—Its prisms, which sometimes present 10 or 12 sides, are variously terminated.—They are divisible in one direction parallel to the axis, and present highly polished laminae.

The crystals are often laterally aggregated, and are sometimes acicular. Sometimes the edges of the prisms are so rounded, that the crystal becomes cylindrical, and is marked with longitudinal striæ or channels.

These cylinders and needles are almost always collected into masses, more or less large, and are usually divergent.

(*Chemical characters.*) This ore melts very easily, even by the flame of a candle. Before the blowpipe it exhales the odor of sulphur, and is principally volatilized in a white smoke, leaving a small residue of white oxide of antimony. When charcoal is employed, much of the melted antimony is absorbed. It is composed of antimony 74, sulphur 26. (*BERGMAN.*) It sometimes contains a little silver, copper, iron, arsenic, gold, cobalt, or nickel; and, when the quantity becomes considerable, is denominated argentiferous, cupreous, &c. sulphuret of antimony.

(*Distinctive characters.*) Its easy fusibility distinguishes it from the oxide of manganese;—and from native antimony it differs in specific gravity, color, and by its sulphureous odor, when heated.—In fact, its great fusibility will also distinguish it from some other minerals, it may resemble.

*Var. 1. RADIATED SULPHURET OF ANTIMONY.** This is by far the most common variety. It is sometimes in distinct crystals, whose forms have already been mentioned. But it more frequently occurs in masses, composed of cylindrical, compressed, or acicular prisms, seldom parallel, but usually more or less diverging, and sometimes stellular, or promiscuously intersecting each other. Its longitudinal fracture is fibrous. The fibres are often broad; and their faces, though sometimes only glistening, frequently present a high lustre and lively polish. Sometimes the mass presents a bladed structure.—This variety passes into the following.

2. FOLIATED SULPHURET OF ANTIMONY.† This variety is less common than the preceding. It is usually in granular distinct concretions, whose fracture in one direction is foliated.

3. COMPACT SULPHURET OF ANTIMONY.‡ This is the rarest variety. Its fracture is finely granular or uneven with a moderate lustre. It is usually associated with the other varieties.

4. PLUMOUS SULPHURET OF ANTIMONY.§ Its color is a dark steel gray, sometimes a little bluish or blackish, and liable to tarnish. It is very tender, and almost friable. It presents itself in capillary crystals, extremely delicate, promiscuously grouped or interlaced, and sometimes collected into small masses, or tufts, which sometimes resemble down.

Before the blowpipe it exhales a white smoke, and a black scoria remains. It is said to contain a little arsenic, and sometimes small portions of silver or gold.

This variety is rare, and often merely a coat on other minerals. It is found near Freyberg in Saxony, Felsobanya in Transylvania, &c.

(*Geological situation of the Species.*) Sulphuret of antimony is the only ore of this metal, which occurs in masses or veins of sufficient extent to be explored. It is found in primitive, transition, and also in secondary rocks. Its gangues are quartz, sulphate of barytes, carbonate of lime, &c. Some specimens of this ore are so penetrated by particles of quartz, that they give fire with steel.

This Sulphuret is often accompanied by other ores of antimony, by the sulphurets of lead, zinc, and iron, gray copper, native arsenic, silver, and tellurium, &c.

* Antimoine sulfuré cylindroïde—aciculaire. *Haüy*. Strahliges Grau Spiesglaserz. *Werner*. Radiated gray Antimony. *Jameson*.

† Blattriges Grau Spiesglaserz. *Werner*. Foliated gray Antimony. *Jameson*.

‡ Dichtes Grau Spiesglaserz. *Werner*. Compact gray Antimony. *Jameson*. § Antimoine sulfuré capillaire. *Haüy*. Brongniart. Federerz. *Werner*. Plumose gray Antimony. *Jameson*.

(*Localities.*) In Auvergne, France, in veins, that traverse gneiss.—At Offenbanya in Hungary, its veins are contained in granular limestone.—It is found also at Freyberg, &c. in Saxony.—Also in Italy, Spain, Norway, England, Scotland, &c.

In the *United States*. In *Missouri*.—In *Virginia*, it exists near Richmond. (*HARDEN.*)—In *Indiana*. (*GIBBS.*)—In *Ohio*, near Zanesville. (*ATWATER.*)—In *Connecticut*, at Harwinton, accompanied by native antimony. (*SILLIMAN.*)—It is said also to exist at East Hartford.—In *Massachusetts*, near South Hadley—and in *Maine*, on Saco river. (*GIBBS.*)

SUBSPECIES 1. ARGENTIFEROUS SULPHURET OF ANTIMONY.

Antimoine sulfuré argentifère. *Haüy.*

It is sometimes in shining six-sided prisms, terminated by diedral summits, and sometimes in small compact masses.

At Freyberg, it is associated with carbonate of iron, galena, &c.—It occurs also in Mexico.

SUBSPECIES 2. NICKELIFEROUS SULPHURET OF ANTIMONY.

Antimoine sulfuré nickelifère. *Haüy.* Nickelspiesglänzerz. *Hausmann.* Nickeliferous Gray Antimony. *Jameson.*

This mineral is composed in part of broad, parallel plates, of a shining white like antimony, and in part of a compact substance, having a lead gray color, and a feeble lustre. It is harder than the common sulphuret; and its specific gravity is between 5.65 and 6.54.

Before the blowpipe, on charcoal, it easily melts, exhaling white fumes, which have the odor of arsenic, and are partly deposited on the coal in the form of a yellow powder; by continuing the heat it is converted into a white, brittle, infusible globule. It is partially soluble in nitric acid, to which it communicates a green color. It contains, according to Stromeyer, antimony 43.80; sulphur 17.71, nickel 36.60, iron and manganese 1.89.

It is found near Treusburg in Nassau, associated with carbonate of iron, galena, and pyritous copper.

SUBSPECIES 3. CUPREOUS SULPHURET OF ANTIMONY.

Antimoine sulfuré cuprifère. *Haüy.*

Its color is a dark metallic gray, or nearly iron black, sometimes with a tinge of red. It occurs in amorphous, brittle masses, with a shining conchoidal fracture.

It is easily fusible, exhaling white vapors. A specimen from the Pyrenees yielded antimony 70, sulphur 9, copper 20, arsenic 1.

It is found in the Pyrenees, and in Siberia.

SPECIES 3. OXIDE OF ANTIMONY.

Antimoine oxidé. *Haüy. Brongniart.* Weiss Spiesglaserz. *Werner.* Prismatic White Antimony. *Jameson.* Antimoine blanc. *Brochant.* Muriated Antimony. *Kirwan.* Spiesglanzweiss. *Hausmann.* White Antimony. *Aikin. Phillips.*

Its color is white, either pure or tinged with yellow or gray, especially at the surface. It is translucent, easily scraped by a knife, tender, and sometimes friable. It occurs in rectangular, four-sided prisms or tables, which are sometimes slightly modified, or in acicular crystals. Sometimes also it is massive, or exists in an earthy state. The tables are often aggregated, and the acicular crystals usually occur in fascicular or stellular groups.—Its structure is foliated in one direction, and its lustre is shining and somewhat pearly. Its specific gravity is between 5.0 and 5.6.

(*Chemical characters.*) Before the blowpipe it decrepitates; sometimes also it melts with great ease even by the flame of a candle, and sometimes it is volatilized either entirely or in part without fusion. It is sometimes a pure Oxide; but a specimen from Allemont yielded Vauquelin oxide of antimony 86, silice 8, iron 3.

In some cases, this Oxide appears to have been produced from the sulphuret of antimony.

It is sufficiently distinguished from zeolite and stilbite by its chemical characters.

(*Geological situation and Localities.*) This Oxide occurs in veins, and usually accompanies the sulphuret and other ores of antimony. Near Allemont in France, it appears in groups of diverging needles, and sometimes forms a crust on native antimony.—At Przibram in Bohemia, it occurs in shining tabular crystals on sulphuret of lead, and is a pure Oxide, according to Klaproth.

*Var. 1. EARTHY OXIDE OF ANTIMONY.** Its color is usually straw yellow, sometimes passing to yellowish or brownish gray. It is sometimes friable, and sometimes indurated with a dull, earthy fracture.—It is usually a mere crust on other ores of antimony.

Before the blowpipe it is in part volatilized, but does not melt.

At Tornavera in Galicia, it invests large crystals of sulphuret of antimony, and has probably arisen from the decomposition of that ore. Indeed the same crystal is sometimes in part a sulphuret of antimony, and in part an Oxide.—In Cornwall, near Padstow, it invests compact sulphuret of antimony.

APPENDIX TO OXIDE OF ANTIMONY.

FERRUGINOUS OXIDE OF ANTIMONY.

Zundererz. *Werner.* Tinder Antimony Blende. *Jameson.*

This mineral is sometimes dark red, and sometimes yellowish. It occurs in leaves, whose texture is sometimes irregularly fibrous; some-

* Antimoine oxidé terreux. *Haüy.* Spiesglas ocker. *Werner.* Antimony ochre. *Jameson.* Spiesglanzocher. *Hausmann.* Antimonial Ochre. *Aikin. Phillips.*

times also it is in dull, friable, ochreous masses. It acquires lustre in its streak.

Before the blowpipe, on charcoal, it is partially volatilized, and the residue is magnetic. A specimen from Clausthal yielded Link oxide of antimony 33, of iron 40, of lead 16, sulphur 2, with some silver. In a specimen from France, Gueniveau found antimony 34, iron 22, lead 12, oxygen 16, silex 14, sulphur 2.

It is found at Clausthal in the Harz; and near Notre Dame des Millieres, where the yellow variety forms a small vein.

SPECIES 4. SULPHURETTED OXIDE OF ANTIMONY.

Antimoine oxidé sulfuré. Haüy. Roth Spiesglaserz. Werner. Red Antimony. Jameson. Aikin. Phillips. L'Antimoine rouge. Brochant. Antimoine hydro-sulfuré. Brongniart. Red Antimonial ore. Kirwan. Rothspiesglanzerz. Hausmann.

Its color is a deep or cherry red, sometimes with a tinge of brown, and sometimes passing to a dull brick red. Its surface is liable to a brownish or irised tarnish. It is tender, and sometimes perfectly friable. It is usually opaque, and preserves its color both in its streak and powder. Its specific gravity is between 4.0 and 4.6.

It is sometimes in capillary crystals with a shining lustre almost metallic, and sometimes nearly adamantine. These crystals are often collected into groups, in which they diverge from a common centre, or are promiscuously aggregated.

It occurs also in amorphous masses, of a dull brick red color, sometimes with a tinge of yellow.—Its masses have sometimes a granular structure.

(*Chemical characters.*) Before the blowpipe it melts, burns with a bluish flame, yields the odor of sulphur, and is entirely volatilized. In nitric acid it becomes covered with a white powder. The acicular crystals from Braunsdorf yielded Klaproth antimony 67.5, oxygen 10.8, sulphur 19.7; = 98.

This ore appears to be produced by a partial decomposition and alteration of the sulphuret of antimony. In the same group, while some crystals remain in the state of a metallic gray sulphuret, others are converted into the state of a red sulphuretted oxide of antimony. Indeed the alteration may sometimes be observed, while it exists at the surface only.

Its color, and more especially its chemical characters, when compared with those of the red oxide of copper, arseniate of cobalt, &c. sufficiently distinguish it from other minerals.

(*Geological situation and Localities.*) This ore accompanies the sulphuret and other ores of antimony. Sometimes it appears in fissures, and sometimes it invests the surface of the sulphuret with acicular crystals or an earthy crust.

It is found in Tuscany;—at Braunsdorf in Saxony;—Kapnic in Transylvania, &c. At the last place the amorphous variety is mixed with minute crystals of sulphur.

In the *United States*. In *Virginia*, near Leesburg, in detached masses in the soil; it has a deep ruby red color. (*HARDEN*.)

GENUS XVIII. *TELLURIUM*.*

This newly discovered metal, in many of its properties, resembles antimony, while in others it is totally distinct. Its color is a shining white, being nearly tin white with a shade of blue, and somewhat approaching the color of zinc. Its structure is foliated, and its specific gravity only 6.11. It is extremely brittle, easily reducible to powder, and on paper leaves a blackish trace. Its hardness is moderate.

It is more fusible than antimony, but less so than lead; and, when slowly cooled, its surface exhibits a radiated crystallization. When heated by the blowpipe, it burns with a bluish flame, greenish at the edges, and may be volatilized in the state of a white oxide with a pungent odor, which is by some thought to resemble that of horse radish.

It is more tender, and less heavy than antimony; and its odor before the blowpipe is different. Its solutions in acids are precipitated by metallic antimony. With nitric acid it forms a limpid solution.

SPECIES 1. NATIVE TELLURIUM.

Tellure natif auro-ferrifere. Haüy. Gediegen Silvan. Werner. Hexahedral Tellurium. Jameson. Le Silvane natif. Brochant. Tellure natif ferrifere. Brongniart. Gediegen Tellur. Hausmann. Native Tellurium. Aikin. Phillips.

When nearly pure, the physical and chemical characters of this ore differ but little from those of pure tellurium.—Its color is nearly tin white, sometimes with a slight tinge of gray or yellow. Its structure is foliated, and its lustre shining and metallic.—It occurs massive, or in grains, which are sometimes aggregated, or in little plates often confusedly grouped, or in crystals, whose primitive form appears to be a rectangular four-sided prism. It is, however, by Haüy supposed to be a rectangular octaedron.—The aforementioned prism is liable to truncations on its terminal or lateral edges, or on its solid angles. The truncations on the terminal edges sometimes produce pyramidal terminations; sometimes indeed the form becomes an octaedron with deeply truncated summits. Its prisms are often short or even tabular.—Several of the preceding modifications have been observed only in some of the subspecies.

It yields easily to the knife; and its specific gravity is between 5.7 and 6.2.

* *Silvan. Werner.*

(*Chemical characters.*) Before the blowpipe, it melts with a moderate heat, burns with a bluish flame, which is often green at the edges, and is volatilized in a white vapor, exhaling a peculiar odor, somewhat like that of horse radish. It contains, according to Klaproth, tellurium 92.55, iron 7.20, gold 0.25.

It is less hard and less heavy than native antimony.

Native tellurium has been found chiefly at Facebay, in Transylvania, where it exists in veins, traversing graywacke and compact limestone. Its gangue is quartz, &c. and it is associated with the sulphurets of lead, zinc, and iron.—It occurs also in Norway.

In the *United States*. In *Connecticut*, at Huntington, associated with ferruginous oxide of tungsten, native bismuth, native silver, &c. (*SILLIMAN'S Jour.* vol. i, p. 405.)

Native tellurium is never entirely free from alloy. It always contains gold, and sometimes iron, silver, lead, copper, and sulphur.—Hence the existence of several subspecies.

SUBSPECIES 1. AURO-ARGENTIFEROUS NATIVE TELLURIUM.

Tellure natif auro-argentifere. *Haüy*. Schriftez. *Werner*. Graphic Tellurium. *Jameson*. *Aikin*. *Phillips*. Le Silvane graphique. *Brochant*. Tellure natif graphique. *Brongniart*. Schrifttellur. *Hausmann*.

Its color is tin white, or light steel gray, with a strong external lustre. It is sometimes massive, but usually in small four or six-sided prisms, variously modified. These prisms are often so arranged in rows, that they more or less resemble written characters; and hence the name of *graphic tellurium*.—Its structure is foliated; and its cross fracture is uneven and glistening. It yields easily to the knife; and its specific gravity is about 5.7.

It contains tellurium 60, gold 30, silver 10. (*KLAPROTH*.)

It has been found only at Offenbanya in Transylvania, where it is in veins, traversing sienite or porphyry. It occurs on the surface of quartz and other minerals, and is associated with the sulphurets of zinc and iron, gray copper, &c.

SUBSPECIES 2. AURO-PLUMBIFEROUS NATIVE TELLURIUM.

Tellure natif auro-plumbifere. *Haüy*. Weiss Silvanerz and Nagyagerz. *Werner*. Yellow Tellurium and Prismatic Black Tellurium. *Jameson*. Weiss and Blatter Tellur. *Hausmann*. Yellow and Black Tellurium. *Aikin*. *Phillips*.

Its color is sometimes silver white with a strong shade of yellow, or nearly brass yellow, and sometimes gray, or a shining blackish gray between lead gray and iron black. It has a foliated structure, and a shining metallic lustre; its cross fracture is uneven. Its specific gravity varies from 7.00 to 10.67. Its laminæ are somewhat flexible, but not elastic. It yields easily to the knife.

It occurs in short hexaedral prisms or tables, or in four-sided prisms, sometimes truncated on the terminal edges, &c. or in little

plates partly inserted in their gangue, and sometimes in masses either lamellar or nearly compact.

Like the other subspecies, when exposed to heat, it melts, and the tellurium is volatilized with its peculiar odor. The gold, which it contains, appears in minute globules. A yellowish white specimen yielded Klaproth tellurium 44.75, gold 26.75, lead 19.5, silver 8.5, sulphur 0.5. In a blackish specimen, he found tellurium 32.2, gold 9.0, lead 54.0, copper 1.3, sulphur 3.0 ;=99.5.

This subspecies has been found only at Nagyag, in Transylvania. It occurs in veins with the sulphurets of lead and zinc, gray copper, &c. traversing porphyry. Its gangues are quartz, brown spar, and carbonate of manganese.

The preceding species is explored as an ore of gold, and sometimes also of silver. Hence the mines, whence it is taken, are called gold mines.

GENUS XIX. CHROME.

This metal, which was discovered by Vauquelin, derives its name from the Greek, *χρῶμα*, *color*, in consequence of the various and very beautiful colors, which its oxide and acid communicate to those minerals, into whose composition they enter, either as essential or accidental ingredients.

Chrome is grayish white, brittle, hard, and has a radiated texture. Its specific gravity is 5.9. It is with difficulty reduced to its metallic state and melted. Neither the metal, nor its oxide is much acted upon by acids. In its highest degree of oxidation, it constitutes Chromic acid, of a ruby red color. Its oxide communicates to glass a lively and durable green, which resists the action of the strongest fire.

(*Uses and Remarks.*) The oxide of Chrome, and some of the saline combinations, formed by the Chromic acid, are employed in the arts, and furnish very beautiful and durable pigments. The artificial chromate of lead has a very fine orange or reddish yellow color, and is ground with oil. This compound is prepared at Philadelphia, the chromic acid being obtained from the native chromate of iron, found near Baltimore, &c. It is sold by the name of Chromic yellow.

The oxide of Chrome is employed at the manufactory of Sèvres, in France, to give a fine deep green to the enamel of porcelain. It is applied without a flux, and melted with the enamel.

In the state of an acid, Chrome is found united with the oxides of lead, and iron, forming the chromates of lead, and iron. If there really exists, as is supposed by some, a combination of the oxides of Chrome and iron, this compound must be arranged under this genus, as a ferruginous oxide of Chrome.—The Chromic acid is found also in the spinelle.

In the state of an oxide, Chrome forms the coloring matter of the emerald, actynolite, and some varieties of diallage and serpentine.

SPECIES 1. OXIDE OF CHROME. MAC CULLOCH.

Its color is bright grass green, or pale yellow. It is sometimes in solid masses, somewhat translucent, and presenting marks of a crystalline structure, and sometimes it is pulverulent and dull.

Before the blowpipe it renders borax green. It is soluble in alkalis with the assistance of heat.

This mineral, recently discovered by Dr. Mac Culloch, is found in Unst, one of the Shetland islands, where it fills cavities in chromate of iron, or invests its surface.

A mineral, containing Oxide of chrome, has been found in France, Department of Saone and Loire, between Creuzot and Couches, where it forms thin beds in a sandstone or breccia.—It is apple green, yellowish or leek green, and yields a pale grayish green powder. It is usually friable; and its specific gravity is about 2.55.—It gives to borax a fine emerald green; and contains, according to Drappier, oxide of chrome 13.0, silex 52.0, alumine 27.0, lime 4.5, oxide of iron 2.0;=98.5. (Leschevin in Lucas.)

GENUS XX. *MOLYBDENA.*

This metal is so nearly infusible in the greatest heat of a furnace, that it can hardly be said to have ever been reduced to a well fused mass. It has generally been obtained in metallic grains feebly agglutinated, and sometimes in small, shining metallic globules. This metal appears to be nearly silver white, brittle, and very hard; and to have a specific gravity of about 8.6.

The action of sulphuric acid converts this metal into an indigo blue or greenish blue oxide; and this blue oxide is by nitric acid converted into a yellowish white powder, which is Molybdic acid.

The metallic molybdates display various colors, some of which are lively and permanent, and will probably become useful in the art of dying.—This genus contains two species.

SPECIES 1. SULPHURET OF MOLYBDENA.

Molybdene sulfuré. *Hauy. Brongniart. Wasserblei. Werner. Molybdena. Kirwan. Aikin. Le Molybdene. Brochant. Rhomboidal Molybdena. Jameson. Molybdankies. Hausmann. Sulphuret of Molybdena. Phillips.*

Its color is lead gray with a shining metallic lustre. It is very soft, and may be scratched by the finger nail, which leaves a shining streak. Its structure and fracture are distinctly foliated in one direction; the laminae separate with ease, are somewhat flexible, often curved, and have a strong metallic lustre.—It is smooth and unctuous to the touch, soils the finger, and, when rubbed on paper, leaves a trace resembling that of graphite or plumbago. It is opaque; and its specific gravity extends from 4.04 to 4.73. It is a conductor of electricity; and, when rubbed on sealing wax, communicates to the wax positive electricity.

It occurs in regular crystals, or in plates, or in small lamellar masses. Its crystals are short six-sided prisms, or tables. The tables are either equilateral or elongated, and sometimes extremely thin;—in some instances the prism is terminated by six-sided pyramids. Their primitive form is probably a right prism with rhombic bases.

(*Chemical characters.*) It is infusible by the blowpipe, but is in part volatilized, exhaling white fumes and the odor of sulphur. By calcination at a high temperature it is converted into molybdic acid. It is also converted into molybdic acid by the action of nitric acid, repeatedly applied, and distilled to dryness. It is composed of molybdena 60, sulphur 40. (*BUCHOLZ.*) A little iron is sometimes present.

(*Distinctive characters.*) The Sulphuret of molybdena strongly resembles graphite or plumbago in its external characters, and was formerly confounded with it. But, if the two minerals be rubbed on white porcelain or any fine pottery, the trace of molybdena has a greenish tinge, and contains numerous little scales, while the trace of graphite is dark gray, and composed chiefly of grains. The structure of molybdena is always foliated, but the texture of graphite is usually granular. By trituration molybdena is reduced into minute plates or scales, whereas graphite is usually converted into a powder. And further, when the two minerals are gently rubbed on white paper, the trace of molybdena is much more shining, than that of graphite.—It is easily distinguished from micaceous oxide of iron.

(*Geological situation.*) This ore belongs exclusively to primitive rocks, in the oldest of which, as granite and gneiss, it most frequently occurs. Sometimes it is disseminated through these rocks in crystals, minute plates, or in masses or nodules of a moderate size. Sometimes it occurs in metallic veins, which traverse these rocks, and is associated with the oxide of tin, ferruginous tungsten, native arsenic, magnetic iron, &c.

(*Localities.*) Near Mont Blanc, it is disseminated in granite.—At Zinnwald in Bohemia, it occurs in veins of tin.—In Norway, Sweden, &c. it is disseminated in granite and gneiss.—In England, Cumberland, near Caldbeck, in six-sided tables in granite.—At Glenelg, in Scotland, it is imbedded in chlorite slate.

In the *United States.* In *South Carolina.*—In *Virginia.*—In *Maryland*, near Baltimore, in granite. (*HARDEN.*)—In *Pennsylvania*, Delaware County, near Chester, it occurs massive, and in regular six-sided tables, imbedded in the white quartz of granite. (*WISTER.*)—Also in Chester County, with sulphuret of iron and pyritous copper. (*WOODHOUSE.*)—In *New York*, on the island of New York, in very flexible folia, and in thicker masses in gneiss;—also in the Highlands; and on Long island. (*PIERCE & TORREY.*)—Also at West Point.

(*MITCHILL.*)—Also in West Chester and Putnam Counties.—In *Connecticut*, at Brookfield.—Also at Saybrook, a small distance northwardly from Pettypaug meeting house, in a vein of quartz traversing gneiss. (*J. D. PORTER.*)—Also at East Haddam.—In *Massachusetts*, at Shutesbury, in foliated masses, and six-sided tables sometimes one inch long, in a vein traversing a granitic rock. (*SILLIMAN.*)—Also at Brimfield, in granite. (*EATON.*)—In *Maine*, at Brunswick, on the banks of the Androscoggin, Sulphuret of molybdena is abundantly disseminated in granite and gneiss. It is sometimes finely crystallized in short hexaedral prisms, or rather in tables, or thin plates. The tables are sometimes equilateral, and sometimes elongated, being more than an inch in length; sometimes also they are very small. In some instances, hexaedral laminæ are superimposed on each other, with a decreasing extent, so as to form a solid somewhat pyramidal. Frequently also it occurs in small foliated masses, varying from one tenth of an inch to two inches or more in diameter. It is sometimes associated with a yellowish or greenish yellow oxide of molybdena in the form of a crust or efflorescence.—Also at Mount Desert, near Pretty Marsh mills, forming narrow veins.

SPECIES 2. OXIDE OF MOLYBDENA.

Molybdena ochre. *Jameson. Phillips.* Molybdanoher. *Hausmann.*

Its color is usually sulphur or straw yellow, and sometimes orange yellow. It occurs in the form of a dull powder, or friable crust.

When heated by the compound blowpipe, a snow white oxide is sublimed.

It is found investing sulphuret of molybdena, or its gangue; sometimes also it occurs between laminæ of the sulphuret.

It has been observed at Corybuy in Scotland; and at Nummedalen in Norway.

In the *United States*. In *Maine*, at Brunswick, it is associated with the sulphuret of molybdena, which it often invests.

GENUS XXI. TUNGSTEN.*

Little can be said with confidence concerning the characters of this metal in a pure state. Chemists have usually obtained it in detached globules, rather than in a well fused mass. Its color is nearly steel gray; it is brittle, and very hard. Its specific gravity, according to Allen and Aikin, is 17.33.

It is fusible in the most intense heat only. Both the metal and its oxide are nearly insoluble in acids; but the oxide, when digested in nitric acid, assumes a lemon yellow color.

* Scheel. *Werner.* Scheelin. *Haüy.* It was discovered by Scheele.

SPECIES 1. YELLOW OXIDE OF TUNGSTEN. SILLIMAN.

For our knowledge of this *new* ore of Tungsten we are indebted to Professor Silliman of New Haven.

Its color is orange or chrome yellow, either light or deep. It occurs both massive and pulverulent.

The massive variety is brittle; its fracture is between conchoidal and small foliated, and its lustre is adamantine. When pure, its specific gravity is 6.0. It has neither smell, nor taste.

This Oxide of tungsten is infusible by the blowpipe, and insoluble in acids. It is, however, readily soluble in warm liquid ammonia, from which it is precipitated white by acids; but the precipitate, by rest, again becomes yellow.

It is found in the *United States*; in *Connecticut*, at Huntington, in a gangue of quartz.—The pulverulent variety forms a crust on the ferruginous oxide of tungsten, or occurs in its cavities.—Both the massive and pulverulent varieties often occur in the interstices, and upon the surface, of the calcareous oxide of tungsten, with which also they are frequently mixed.

It appears that all the known ores of tungsten are found in the same mine at Huntington.

SPECIES 2. CALCAREOUS OXIDE OF TUNGSTEN.

Scheelin calcaire. Haüy, Brongniart. Schwerstein. Werner. Hausmann. Tungsten. Kirwan. Aikin. Phillips. La Pierre pesante. Brochant. Pyramidal Tungsten. Jameson.

This ore has the general aspect of a stone; but its specific gravity lies between 5.57 and 6.10. Its colors are gray or whitish, yellowish white or yellowish gray, and sometimes brown. Its surface has often a resinous lustre, and is sometimes tarnished. It is more or less translucent, or even semitransparent, when crystallized. It may be scratched by a knife, and is easily broken.

Its structure is foliated, but often imperfectly, and its fracture is uneven or conchoidal; its lustre is shining and a little resinous. The laminæ separate in directions parallel to the sides both of a cube and octaedron.

It is sometimes amorphous, and frequently in crystals, whose general form is an octaedron, bounded by isosceles triangles. Or it may be called a double four-sided pyramid, of which any two contiguous sides, belonging to opposite pyramids, contain an angle, at the common base, of $113^{\circ} 36'$. This octaedron is sometimes cuneiform—or bevelled on its lateral solid angles, or on the common base.—The primitive form is also an octaedron, but more acute, than the one just mentioned.—Sometimes also it presents the primitive octaedron with its summits and oblique lateral edges truncated.

(*Chemical characters.*) It becomes opaque before the blowpipe, and decrepitates, but is infusible. By digestion in nitric acid, it is converted into a yellow powder, which is the peroxide of tungsten. A crystallized specimen from Schlackenwald yielded Klaproth yellow oxide of tungsten 77.75, lime 17.60, silex 3.0; =98.35. Another from Bitsberg yielded Scheele oxide of tungsten 65, lime 31, silex 4. According to Berzelius, it is composed of tungstic acid 80.4, lime 19.4; =99.8.—While some chemists consider the tungsten in this mineral as a peroxide, others regard it as an acid, and give to this species the name of tungstate of lime.

(*Distinctive characters.*) The preceding characters, and more especially the yellow color, which its powder assumes in nitric acid, will sufficiently distinguish it from the oxide of tin, carbonate of lead, and sulphate of barytes, all of which it may somewhat resemble.

(*Geological situation and Localities.*) This ore occurs in primitive rocks only, and is associated with the oxide of tin, ferruginous tungsten, brown hematite, quartz, mica, &c.

It is found at Schlackenwald, &c. in Bohemia;—Bitsberg in Sweden;—Pengilly in Cornwall;—Oisans in France, &c.

In the *United States*; in *Connecticut*, at Huntington, it occurs in quartz, and is associated with the yellow oxide of tungsten.

SPECIES 3. FERRUGINOUS OXIDE OF TUNGSTEN.

Scheelin ferruginé. Hauy. Brongniart. Wolfram. Werner. Hausmann. Kirwan. Brochant. Aikin. Phillips. Prismatic Wolfram. Jameson.

Its color is nearly black, sometimes dark grayish or brownish black, with somewhat of a metallic aspect. It is opaque, and both its streak and powder are dark reddish brown or a deep violet. Its specific gravity usually lies between 6.4 and 7.4. It is brittle, and yields to the knife, but sometimes gives sparks with steel.

Its structure is foliated in one direction, and its lustre is resinous or nearly metallic, and more or less shining, or sometimes only glimmering; its fracture is uneven with but little lustre. When in laminated masses, its fracture, under certain points of view, has a fibrous aspect.

Its crystals are prismatic, or tabular. Their primitive form, which it sometimes presents, is a rectangular four-sided prism. (Pl. V, fig. 29.)—This prism is sometimes truncated on its solid angles (Pl. V, fig. 30.), and, in addition to this, its lateral edges may also be truncated, or bevelled.—Sometimes each extremity of the prism supports a pyramid, whose faces correspond to the lateral edges.—Sometimes the prism has ten sides, and each summit twelve faces, ten of which correspond to the sides of the prism.—Sometimes the prism is oblique-angled, and terminated by a bevelment, while the edges around the bevelment are truncated.—It occurs also in broad six-sided prisms, terminated by

four-sided summits; two faces of each summit correspond to the broader faces of the prism, and meet in a line.—Sometimes it presents rectangular four-sided tables, whose edges and angles are modified by truncation or bevelment.—It also occurs in octaedrons.—Its crystals are sometimes large; but they are often badly defined.

This Oxide of tungsten occurs also in plates, or in foliated masses, whose laminæ easily separate by percussion. Its folia are sometimes small; and its masses often present curved, lamellar distinct concretions.

(*Chemical characters.*) Before the blowpipe it decrepitates, but is infusible, or is changed into a scoria. According to Vauquelin, it contains oxide of tungsten 67.0, oxide of iron 18.0, oxide of manganese 6.25, silex 1.5;=92.75.—D'Elhuyart found oxide of tungsten 64.0, of iron 13.5, of manganese 22.0;=99.5. According to Berzelius, it contains oxide of tungsten 74.67, of iron 17.59, of manganese 5.64, silex 2.10. The proportion of iron and manganese is sometimes 30 per cent. When its powder is digested in muriatic acid, a yellow oxide of tungsten appears.

(*Distinctive characters.*) It somewhat resembles the magnetic and specular oxides of iron; but it is heavier, and is not affected by the magnet.—Its structure is more distinctly foliated, than that of the oxide of tin; it is also less hard, and the color of its powder is different.

(*Geological situation and Localities.*) This ore belongs chiefly to primitive rocks, and often accompanies the oxide of tin.—Thus it occurs in the tin mines of Bohemia, Saxony, and Cornwall.—In Siberia, it is associated with the beryl and topaz.—Near St. Leonhard, in the Department of Upper Vienne, it occurs in considerable quantities in a vein of quartz.—In the Harz, it occurs in veins traversing graywacke.—In Rona, one of the Hebrides, it is in veins traversing gneiss.—In England, at Caldbeck.

In the *United States*. In *Connecticut*, at Huntington, it occurs both massive, and in octaedral crystals in quartz with native bismuth, native silver, &c.; it is brownish black, gives sparks with steel, and the mean specific gravity of the massive variety is 6.05. (*SILLIMAN*. See Amer. Journ. of Science, vol. i, p. 405.)

It is less rare than the preceding species.

GENUS XXII. *TITANIUM*.*

Titanium is with great difficulty obtained in a metallic state, and, of course, its properties have been but little examined. It is almost infusible.

Titanium has hitherto been found in the state of an oxide only, either pure, or combined with the oxides of other metals, or with certain earths. It exhibits a considerable diversity of external character, but it has seldom much of a metallic aspect.

* Menak. *Werner*. It was first found in Menachan, Cornwall.

If the native oxide of Titanium be fused with four times its weight of potash, and if this fused mass be repeatedly digested in water, a whitish powder appears, which is oxide of Titanium. This white oxide is soluble in nitric acid, from which it is precipitated brownish yellow by the prussiate of potash, and brownish red by tincture of galls. If the solution be concentrated, the latter precipitate somewhat resembles curdled blood.

If the native oxide be fused with six times its weight of carbonate of potash, and the melted mass digested in water, the white powder obtained will be a carbonate of Titanium, which is soluble in nitric acid with effervescence.

This metal, to which Klaproth gave the name, *Titanium*, was first discovered by Rev. Mr. Gregor of Cornwall.

SPECIES 1. RED OXIDE OF TITANIUM.

Titane oxidé. *Haüy*. Titane Ruthile. *Brongniart*. Rutil. *Werner*. Hausmann. Rutile. *Jameson*. Le Ruthile. *Brochant*. Titanite. *Kirwan*. Aikin. *Phillips*. It has also been called red schorl.

The ordinary color of this ore is red with a tinge of brown; but its color varies from blood red to reddish brown, copper or yellowish red, and sometimes to grayish red, or even steel gray, especially at the surface. Its external lustre is usually considerable, and often more or less metallic. It is opaque, or translucent, sometimes at the edges only, and some crystals are semitransparent.—It scratches glass, and sometimes quartz; and, when not too brittle, gives sparks with steel. Its specific gravity lies between 4.10 and 4.25.

Its structure is foliated; its cross fracture is conchoidal or uneven; and it has usually a strong lustre, especially on the surface of the laminae, either adamantine or metallic.—Its laminae separate in two directions, parallel to the axis, and at right angles to each other, and lead to its primitive form, which is a rectangular prism with square bases; the side of the base is to the height of the prism nearly as 10 to 11, and the prism is divisible in the directions of the diagonals of its bases.—It often breaks into cubical fragments.

It occurs also in masses, whose texture is *fibrous*, or *granular*, or nearly *compact*, or in grains, and, according to Lucas, it is sometimes in a pulverulent state.

This Oxide, though sometimes massive, &c. is usually in prismatic crystals, whose forms are very often imperfect. Sometimes it presents the primitive form already mentioned. In some cases, the prism is terminated by four-sided pyramids, whose faces correspond to the sides of the prism;—sometimes also an eight-sided prism is produced by truncations on the lateral edges, or the same edges are even bevelled.—The prisms are frequently *geniculated*, that is, two prisms are united, base to base, at an obtuse angle, and form a kind of *knee*

(Pl. V, fig. 31 and 32.); sometimes even four prisms are thus united, forming three joints.—It occurs also in six-sided prisms, whose extremities are sometimes rounded (Pl. V, fig. 33.); this convexity seems to arise from a tendency to six-sided, pyramidal terminations.—The primitive form is liable to several other modifications.

These prisms are usually marked with longitudinal striæ. Sometimes they become cylindrical; and sometimes they are traversed by seams, perpendicular to the axis.—They are often acicular or even capillary, sometimes very long, and sometimes collected into fascicular groups, or are reticulated.

(*Chemical characters.*) This Oxide is infusible by the blowpipe, unless a flux be employed. With borax it melts into a transparent reddish yellow glass. It is sometimes a pure oxide, according to Klaproth; and sometimes it contains a little iron, chrome, or silex.

(*Distinctive characters.*) It is sensibly harder than the silico-calcareous oxide of titanium, from which it also differs in crystalline form and structure, and usually in color.—Its structure is more distinctly foliated, than that of the oxide of tin, and it has a lower specific gravity.

RETICULATED RED OXIDE OF TITANIUM.* It is composed of acicular or capillary crystals, crossing each other, like the threads of a net. The interstices are sometimes triangular. This subvariety is sometimes applied to the surface of other minerals, and is sometimes rendered very beautiful by being embraced in transparent quartz. It is sometimes blood red.

(*Geological situation.*) This Oxide appears to belong exclusively to primitive rocks, more particularly granite, gneiss, mica slate, or limestone. It is attached to the surface of these rocks, or disseminated in the masses or veins of quartz, feldspar, &c. which these rocks contain.—Sometimes also it occurs in detached crystals in alluvial earths, proceeding from primitive rocks; and in this case its prisms usually have blunted edges, or are broken.

(*Localities.*) In Hungary, in the Carpathian mountains, it occurs in mica slate or gneiss, in a gangue of quartz, and is sometimes reticulated.—At St. Gothard, it is often reticulated, and appears on the surface of granite, gneiss, feldspar, quartz, and mica, or is even mingled with crystals of mica.—In France, near St. Yrieix, it occurs in alluvial earths.—In Norway, at Arendal, in a vein of granite, traversing gneiss.—In Scotland, at Cairngorm, and near Killin, &c.—At Fernbo, near Sahla in Sweden, a *chromiferous* oxide of titanium is found in veins in a greenish talcose rock.

In the *United States*. In *South Carolina*, in Pendleton and Union Districts.—In *North Carolina*, in the interior of the State. (CLOUD.)

* Titane Ruthile reticulé. Brongniart.

—In *Virginia*, near Richmond, it is sometimes massive and granular—and sometimes compact, of a blood red color, and imbedded in milk white quartz; it is associated with the ferruginous oxide of titanium. (*BRUCE.*)—Also in Randolph County, in acicular crystals in quartz. (*WISTER.*)—Also in the Counties of Amherst, Campbell, and Bedford, disseminated in loose masses of quartz on the soil. It is in four-sided prisms, sometimes truncated on the lateral edges, and often so compressed and striated as to become nearly cylindrical. These prisms, sometimes terminated by one face oblique to the axis, generally present pyramidal terminations, more or less regular, and, in some instances, the pyramid is perfect. The crystals, sometimes nearly four inches long, are often geniculated, and sometimes so frequently as to change the general aspect of the crystal. (*T. D. PORTER.*)—In *Maryland*, near Baltimore, it is light red, prismatic and laminated, in a yellowish quartz. (*BRUCE.*)—Also 8 miles from Baltimore, with white augite in dolomite;—also about 20 miles from Baltimore, on the York and Lancaster road, in the primitive limestone, which contains necronite and fetid quartz. (*HARDEN.*)—In *Delaware*.—In *Pennsylvania*, Chester County, at London Grove, its crystals are imbedded in granular limestone, and associated with the silico-calcareous oxide. (*CONRAD.*)—Also in Delaware County, its crystals have been found adhering to an insulated mass of smoky quartz, or even penetrating through the mass. (*CLOUD.*)—Also at East Marlborough, either loose in the soil, or imbedded in limestone; it has a high metallic lustre, and is associated with ferruginous oxide of titanium. (*JESSUP.*)—In *New Jersey*, Bergen County, near Schuyler's copper mines, in an insulated mass of bluish quartz; the crystals are hexaedral prisms with rounded summits, of a steel gray color, with a strong metallic lustre. (*BRUCE.*) In *New York*, near Kingsbridge, on the island of New York, this Oxide is disseminated in veins, which traverse primitive limestone, and which are composed of fetid quartz, feldspar, mica, and limestone. It occurs amorphous, or in small, quadrangular, prismatic, semitransparent crystals, which are sometimes geniculated, and sometimes acicular; its color varies from dark blood red to a light red—also on Hudson's river, it occurs both crystallized and amorphous, of a dark grayish red, with a strong metallic lustre, and translucent at the edges; its gangue is carbonate of lime. (*BRUCE.*)—In *Connecticut*, near New Haven.—Also at Oxford, in large geniculated crystals in mica slate. (*SILLIMAN.*)—Also at Litchfield, sometimes reticulated on mica. (*BRUCE.*)—In *Massachusetts*, Hampshire County, at Worthington, in prismatic, striated crystals, imbedded in a white quartz, which is said to occur in hornblende slate. (*BRUCE.*)—Also at Leyden, in loose masses of quartz and tremolite; its crystals are four or

eight-sided prisms, deeply striated, sometimes acicular, and sometimes geniculated; its colors vary from blood red to deep brownish red. (*HITCHCOCK*.) This locality furnishes fine specimens, sometimes as large as the finger.—Also in *Maine*, at Topsham.

The *Ligurite*, from the mountains of Liguria, is said to be a variety of this Oxide.

SPECIES 2. FERRUGINOUS OXIDE OF TITANIUM.

Titane oxidé ferrifère. *Haüy*. Titane Menakanite. *Brongniart*.

Its color is black, often grayish or iron black, and sometimes brownish black; and it is perfectly opaque. It occurs in masses of moderate size, and in angular grains, which are frequently rounded or flattened, and possess very little external lustre.—It has also been observed in prismatic crystals.

Its fracture is, in most cases, imperfectly foliated in one direction, while in other directions it is more or less conchoidal or uneven; its lustre is glistening, and almost metallic. In some specimens the texture is compact.—It has often the hardness of feldspar. It is easily broken; and its specific gravity lies between 4.27 and 4.67. It often has a feeble action on the needle, and, when reduced to powder, it is usually moved by the magnet.

(*Chemical characters.*) With the exception of one variety, it is infusible by the blowpipe. It appears to be essentially composed of the oxides of titanium and iron; but the proportions are extremely various, and it sometimes embraces other substances. In fact, it appears to pass by imperceptible shades into magnetic iron sand, of which some well characterized varieties contain from 5 to 15 per cent. of the oxide of titanium.

It, however, differs from magnetic iron sand by never possessing a strong magnetic power, and by being sometimes entirely destitute of it.

Several varieties have received distinct names.

Var. 1. MENACHANITE. KIRWAN. JAMESON.* Its color is grayish or iron black, and remains unaltered in the streak. It is feebly attracted by the magnet; and may be easily scratched by steel. It occurs in opaque, small, rounded grains, which have a glimmering surface, and sometimes resemble gunpowder.

A specimen from Cornwall yielded Klaproth oxide of titanium 45.25, magnetic oxide of iron 51.0, silex 3.5, oxide of manganese 0.25. In another from Botany Bay, Chenevix found oxide of titanium 40, oxide of iron 49, silex 11.

It is less hard than magnetic iron sand.

* Menakan. *Werner*. Le Menakanite. *Brochant*. Titaneisenstein. *Hausmann*. Menachanite. *Aikin*. Menaccanite. *Phillips*.

(*Localities.*) This variety was first found in the valley of *Menachan*, in Cornwall; and hence its name. It there occurs in the bed of a rivulet in the form of sand, mingled with grains of quartz.—In Liguria, its grains are imbedded in mica slate. (Prof. *VIVIANI*.)

2. NIGRINE.* *AIKIN. PHILLIPS*. It is found in grains or rolled pieces, whose color is *black* or brownish black; and hence its name. Its streak is yellowish brown. It is scarcely, if at all, affected by the magnet.

In a specimen from Transylvania, Klaproth found oxide of titanium 84, oxide of iron 14, oxide of manganese 2. But in another from the Uralian Mountains, Lowitz found oxide of titanium 53, of iron 47.

(*Localities.*) At Ohlapian, in Transylvania, it occurs in alluvial earths, and is mixed with the red oxide of titanium, garnets, cyanite, &c. and with fragments of granite and gneiss.—Also in the island of Ceylon.

3. ISERINE.† *JAMESON*. This variety also occurs in grains or pebbles; and its color is iron or brownish black, both in the mass and in its streak. It is not easily scratched by a knife; and its fracture is conchoidal in all directions. Its lustre, either strong or only glistening, is somewhat metallic.—It is very feebly magnetic.

According to Jameson, it melts by the blowpipe into a blackish brown glass. A specimen from the river Don, analyzed by Thomson, yielded oxide of titanium 48, oxide of iron 44, oxide of uranium 4;=96. The uranium sometimes equals 10 per cent. and is sometimes absent. In a specimen from the Riesengeberg, Klaproth found oxide of titanium 28, of iron 72;—and in another from Franconia, oxide of titanium 22, of iron 78.—Many specimens, referred to Iserine, appear to be *titaniferous* oxide of iron.

(*Localities.*) This variety was first found at the base of the Riesengeberg in Bohemia, near the river *Iser*; and hence its name. It is there disseminated in sand, which appears to have originated from granite.—In Scotland, in the bed of the river Don, with magnetic iron sand; and also in gneiss in the same country.—In England, on the banks of the Mersey, opposite Liverpool, with magnetic iron sand.

(*Geological remarks.*) It appears from the preceding details, that, although this Oxide has most frequently been found in alluvial earths, it probably belongs to primitive rocks, from the disintegration of which it has proceeded.

In the *United States*. In *South Carolina*, it occurs in Union District.—In *Virginia*, near Richmond; it is sometimes compact, and sometimes granular, and is associated with the red oxide of titanium. (*BRUCE*.)—In *Pennsylvania*, at East Marlborough, in the fissures of limestone with calcareous spar and quartz; it occurs both massive, and in crystals, often cylindrical, longitudinally striated, and some-

* Nigrin. *Werner*.

† Iserin. *Werner*. Iserine. *Aikin, Phillips*.

times terminated by a four-sided pyramid, whose faces are inclined to the sides of the prism at about $59^{\circ} 30'$; it is black, both in mass and powder, and acts very feebly on the needle. (*JESSUP.*)—In *New Jersey*, it is said to occur at Sparta.

APPENDIX TO FERRUGINOUS OXIDE OF TITANIUM.

CRICHTONITE. *JAMESON.*

Craitonite. Bournon.

It occurs in small, opaque crystals, whose lustre is splendid, and somewhat metallic. Their form is usually a very acute rhomb with angles of about 18° and 162° . Two opposite solid angles, forming the summits of this rhomb, are sometimes truncated, or even replaced by more than one face.

Its color varies from steel gray to velvet black. Its structure is more or less foliated in one direction; and its fracture is uneven or conchoidal. It is harder than fluat of lime, but does not scratch glass.

It is with difficulty fusible by the blowpipe. According to *Berzelius*, it is composed of oxide of titanium and of iron in nearly equal proportions.

It has been found near Oisans in France, in veins, which traverse primitive rocks, and contain the octaedral oxide of titanium.

Its name is in honor of Dr. *Crichton* of Petersburg.

SPECIES 3. SILICO-CALCAREOUS OXIDE OF TITANIUM.

Titane siliceo-calcaire. *Hauy.* Gelb Menakan-erz and Braun Menakan-erz. *Werner.* Titane Nigrine. *Brongniart.* Le Nigrine. *Brochant.* Calcareo-siliceous titanitic ore. *Kirwan.* Prismatic Titanium ore. *Jameson.* Sphen. *Hausmann.* Sphene. *Aikin.* *Phillips.*

This ore, which has nothing of a metallic aspect, presents a considerable variety of colors, most of which, however, may be referred to brown or yellow. Thus it is sometimes a deep chestnut or clove brown, hair brown, yellowish or reddish brown, or even violet or blackish brown; sometimes it is yellow of different shades, as isabella, sulphur, or wax yellow, yellowish gray or yellowish white; and sometimes it is grass green, greenish or grayish white, or bluish gray. Its powder is grayish or yellowish white.—It is opaque, or translucent, sometimes at the edges only, and sometimes the paler crystals are transparent.

Its structure is more or less distinctly foliated in two directions; its fracture is imperfectly conchoidal or even; and its lustre is shining or glistening, and a little resinous.—It usually scratches glass; but, though easily broken, is with some difficulty reduced to a fine powder.

Its specific gravity varies from 3.23 to 3.60. One variety is rendered electric by heat, and, as is usually the case, exhibits both electricities.

This Oxide sometimes occurs in small amorphous masses, or in irregular grains, and very often presents itself in crystals, whose

primitive form appears to be an obtuse octaedron, composed of two four-sided pyramids with rhombic bases. Nine or ten secondary forms have been observed.

It sometimes presents the primitive form with two edges on each pyramid truncated. But its more common form is an oblique-angled four-sided prism, whose extremities usually exhibit a greater or less number of faces, oblique to the axis; the obtuse angle of this prism is about $136^{\circ} 50'$.—Sometimes this prism is bevelled at each extremity (Pl. V, fig. 34.) by planes, standing on the obtuse lateral edges of the prism, and meeting each other at an angle of 60° .—Sometimes the preceding form is also bevelled on the solid angles, formed by the acute lateral edges at the base (Pl. V, fig. 35.), and the bevelling faces are parallel to the sides of the primitive octaedron.—Sometimes two obtuse solid angles of the prism, one at each base and diagonally opposite, are obliquely bevelled (Pl. V, fig. 36.); so that the prism becomes terminated by triedral pyramids.—Sometimes the prism is truncated on the four solid angles, where the obtuse lateral edges meet the base (Pl. V, fig. 37.); in addition to which the solid angles, formed by the acute edges at the base, are also sometimes bevelled.—In fine, this prism sometimes becomes hexaedral;—and sometimes it appears without any truncation or bevelment. (Pl. V, fig. 38.)

The crystals are sometimes large, and sometimes very small; and some of them are much compressed or flattened; the lustre of their surface is sometimes very strong.

In some instances two crystals are so applied to each other by their lateral faces, as to form a projecting edge on one side, and a small *channel** on the other. Sometimes four crystals are thus grouped.

The crystals, which are thus united, become electric by heat, and their two summits possess opposite electricities.

(*Chemical characters.*) On charcoal before the blowpipe, it is partially and difficultly fusible into a dark brown enamel. In a specimen from Passau, Klaproth found oxide of titanium 33, silex 35, lime 33;=101. A brownish specimen from Arendal yielded Abilgaard oxide of titanium 58, silex 22, lime 20.

(*Distinctive characters.*) It differs from epidote and actynolite in its crystalline structure.—From the red oxide of titanium it may be distinguished by the form of its crystals, or its inferior hardness, or color.—It is less hard, and less heavy, than the oxide of tin.

(*Geological situation and Localities.*) This species has been found chiefly in primitive rocks, in which it is sometimes so disseminated, as to form almost a constituent part. At Passau, in Bavaria, it is disseminated in sienite.—In Norway, at Arendal, &c. it occurs in granite, and

* Titane siliceo-calcaire canaliculé. *Hauy*.

in those primitive aggregates, which contain beds of magnetic iron ; it is sometimes associated with augite, wernerite, epidote, hornblende, &c. —Near Nantz, in France, it occurs in granite with hornblende.—Near Andernach, it is in very small, yellowish crystals, disseminated in sand.—Near Dissentis, on Mount St. Gothard, it occurs in channelled groups on granite, with chlorite and crystals of adularia. The titanium from this locality is electric by heat.—In Scotland, in the hills of Galloway, and in Ben Nevis, &c. in sienite.

In the *United States*. In *Maryland*, at Petapsco Falls, 10 miles from Baltimore, its crystals are disseminated in granite ; and at the Bare Hills in feldspar. (*GILMOR.*)—In *Pennsylvania*, near the Falls of the Schuylkill, 5 miles from Philadelphia, in granite or gneiss, or in veins of quartz, which traverse these rocks ; (*WISTER.*)—also at London Grove, in Chester County, in granular limestone, which also contains crystals of the red oxide of titanium and of yellow tourmaline. (*CONRAD.*)—Also near Philadelphia, at the end of the canal road, in a quarry of hornblende rock ; it is sometimes in dull, wax yellow octaedrons, truncated on the obtuse angles. (*LEA.*)—In *New Jersey*, at Newton, in Sussex County, in small, semitransparent, yellowish, rhomboidal prisms, imbedded in lamellar carbonate of lime with graphite ;—also at Wantage, in the same County, in yellow, flat, rhomboidal prisms, terminated by trihedral summits ; these crystals, sometimes transparent, are imbedded in an aggregate of hornblende and feldspar, which constitutes a vein, traversing a granitic mountain. (*BRUCE.*)—In *New York*, at Kingsbridge, in small, rhomboidal prisms with diedral summits, of a light dove color, in primitive limestone ;—also on Staten island, near Fort Richmond, in yellowish gray crystals, sometimes large, in a gangue of feldspar and dark green hornblende ;—also near Peekskill, in an aggregate of feldspar, quartz, and hornblende ;—also near Lake George, in clove brown crystals, in an aggregate of feldspar and hornblende with graphite ;—also at Ticonderoga, in large, yellowish gray, rhomboidal prisms with diedral summits, in feldspar with hornblende and graphite. The specimens from Staten island, discovered by Drs. Prince and Bloodgood,—from Peekskill, discovered by Dr. Langstaff,—and from Ticonderoga, discovered by Col. Gibbs, are said greatly to resemble those of the same oxide from Arendal in Norway. (*BRUCE.* See *Min. Journ.* v. i.) —Also near West Farms, in very small, reddish brown, oblique-angled, four-sided prisms, generally bevelled on the obtuse solid angles, in a compact feldspar. (*PIERCE & TORREY.*)

The *Semeline* from Andernach is said to be a variety of this Oxide.

SPECIES 4. OCTAEDRAL OXIDE OF TITANIUM.

Titane Anatase. *Brongniart.* Anatase. *Haüy. Brochant. Phillips.* Octaedrit. *Werner.* Octahedrite. *Jameson. Aikin.* Anatas. *Hausmann.*

It is almost always crystallized in acute, elongated octaedrons, consisting of two pyramids, whose faces are isosceles triangles, and whose bases are squares. The sides of these pyramids are inclined at the common base at an angle of $137^{\circ} 10'$; and the plane angles at the summits are each $40^{\circ} 8'$. The former angle, according to Phillips, is $136^{\circ} 47'$. This is the primitive form, and is divisible in directions parallel to all the sides, and to the common base, thus indicating the form of the integrant particles.

Sometimes the summits of the octaedron are truncated—sometimes they are replaced by four triangular faces (Pl. V, fig. 39.), standing on the sides of the pyramid, in addition to which the common base of the two pyramids is sometimes truncated;—in some cases, the summits of the octaedron are replaced by eight triangular faces.—The crystals are small; their surface has a strong lustre, and is sometimes marked with feeble transverse striæ.

Its colors are blue of various shades, sometimes indigo or blackish blue, brown or blackish brown, and sometimes pass to dark reddish or yellowish brown. Those varieties, which appear dark brown in certain positions, exhibit a metallic gray, when favorably situated to reflect the light. By transmitted light, it often appears greenish yellow. It is opaque, or translucent, and sometimes nearly transparent.

This ore of titanium is easily broken; and its fracture is foliated with a strong lustre, nearly metallic, or somewhat adamantine. It scratches glass; has a specific gravity of 3.85; and is a conductor of electricity.

(*Chemical characters.*) Before the blowpipe it is infusible by itself. With borax it is fusible into a glass, whose color varies according to the degree of heat, and the quantity of borax employed. Thus, with an equal quantity of borax, the glass is often emerald green, and, on cooling, crystallizes in needles; but, with a greater quantity of borax, a hyacinth red or reddish brown glass is obtained, which passes to blue or white, or again returns to reddish brown, according to the degree of heat. By the analysis of Vauquelin, it is nearly a pure oxide of titanium, sometimes containing a little silex.

It is distinguished from minute crystals of the sulphuret of zinc by its greater hardness and crystalline form.

(*Localities.*) This is a very rare mineral. It was first observed in Oisans, in Dauphiny, where it occurs in veins, which traverse granite and other primitive rocks, and is associated with quartz, feldspar, chlorite, and axinite.—In New Castile, it occurs in granite. (*LUCAS.*)—In Norway, it has been found in cavities in transition limestone.—At St. Gothard, Switzerland, it is associated with rose red fluuate of lime.

GENUS XXIII. URANIUM.

Metallic Uranium is obtained with great difficulty, and its properties have been but little examined. According to Klaproth, its color is a dark gray with a metallic lustre. It has a fine granular texture. Its specific gravity is 8.1, or, according to Bucholz, 9.00.

This metal is very difficultly fusible. Its oxide is soluble in diluted nitric acid, affording a yellowish solution, from which prussiate of potash throws down a deep brownish red precipitate, while that with the pure alkalis is lemon yellow. With tincture of galls it yields a small quantity of a blackish precipitate; but, on the addition of an alkali, the precipitate is copious and chocolate brown.—To the enamel on porcelain this oxide imparts a deep orange color.

It was called *Uranium* by Klaproth, its discoverer, in allusion to the name, given by the German Astronomers to the planet Herschel, and derived from the Greek *ουρανός*.

SPECIES 1. BLACK OXIDE OF URANIUM.

Urane oxidulé. *Hauy. Brongniart. Pecherz. Werner. Pitch ore. Jameson. L'Urane noir. Brochant.*
Sulphurated Uranite. *Kirwan. Pechuran. Hausmann. Pitch Blende. Aikin. Phillips.*

The color of this rare ore is black, often brownish, bluish, or grayish black; and its powder has the same color, as the mass. It is perfectly opaque. Its specific gravity lies between 6.37 and 7.50.

It is usually in amorphous masses, whose fracture is imperfectly conchoidal or uneven, and somewhat shining with the lustre of pitch or resin. Sometimes, however, its structure is granular, or slaty in one direction; or its masses may be said to be composed of lamellar or granular concretions. It is sometimes globular or reniform. It may without difficulty be scratched by a knife. It is a conductor of electricity.

(*Chemical characters.*) It is infusible by the blowpipe. It dissolves in nitric acid with a disengagement of nitrous gas, and yields a yellowish solution. A specimen from Joachimsthal yielded Klaproth uranium slightly oxidated 86.5, sulphuret of lead 6.0, magnetic iron 2.5, silice 5.0.

(*Distinctive characters.*) Its high specific gravity, its fracture, and the black color of its powder distinguish it from blackish sulphuret of zinc.—It is heavier than chromate of iron, and does not, like that ore, communicate to borax a green color.—Its fracture and the color of its powder distinguish it from the ferruginous oxide of tungsten.

(*Geological situation and Localities.*) This Oxide of uranium is found in small masses, disseminated in metallic veins in primitive rocks, and accompanying the sulphurets of lead, copper, silver, pyritous copper, native arsenic, ores of cobalt, &c. sulphate of barytes, carbonate of lime, indurated clay, &c. It is also associated with the green oxide of uranium.

It has been found at Joachimsthal in Bohemia; Schneeberg, &c. in Saxony; Kongsberg in Norway; and in Cornwall.

SPECIES 2. GREEN OXIDE OF URANIUM.Urane oxidé. *Haüy*. *Brongniart*. Uranoxyd. *Hausmann*.

The colors of this Oxide vary from emerald or grass green to yellowish green, yellowish brown, and yellow of different shades. Indeed the same crystal is sometimes partly green and partly yellow. It is sometimes crystallized, and sometimes amorphous. Its specific gravity lies between 3.12 and 3.30. It is brittle, easily scraped by a knife, and is sometimes friable.

In nitric acid it dissolves without effervescence, yielding, when pure, a lemon yellow solution, if the acid be saturated. It usually decrepitates before the blowpipe, but is infusible. In a green specimen from Cornwall, Gregor found oxide of uranium 74.4, water 15.4, oxide of copper 8.2;=98. In a specimen from Autun, Berzelius found oxide of uranium 72.15, water 15.70, lime 6.87, oxides of tin and manganese with silex and magnesia 1.55, gangue 2.50.

Var. 1. CRYSTALLIZED GREEN OXIDE OF URANIUM.* Its ordinary colors are emerald or grass green, yellowish green, greenish or sulphur yellow. It is more or less translucent, or even transparent, and has often a strong external lustre.

The primitive form of its crystals is a rectangular prism with square bases; and it sometimes presents this form, either perfect, or truncated on the terminal edges, or on the solid angles, or on all the edges. It frequently appears in small rectangular laminæ, or in tabular crystals, sometimes elongated, and sometimes converted into six or eight-sided tables by truncations on the edges.—Sometimes the crystals are octaedrons, either entire, or with truncated summits; when very deeply truncated, it may be described as a tabular crystal, bevelled on its narrow faces.—Its structure is foliated; and mechanical division is most easily effected in the direction of the terminal planes of the prism.

In some cases the laminæ are so grouped as to resemble a fan or sheaf; in other cases they are irregular, and appear like mere scales or thin plates on the surface of other minerals.—These laminæ, when separated, have a shining and somewhat pearly lustre, and are easily broken.

(*Distinctive characters.*) It much resembles green mica; but the laminæ of mica are flexible and elastic, while those of uranium are brittle, and do not bend; and further, mica is not soluble in nitric acid.—The solution of this Oxide in nitric acid does not yield a blue precipitate with ammonia, unless in small quantity from the accidental presence of copper, and may thus be distinguished from solutions of the green ores of copper.—It does not, like muriate of copper, communicate a greenish blue color to flame.

* Urane oxidé micacé. *Brongniart*. Uran Glimmer. *Werner*. Pyramidal Uranite. *Jameson*. L'Urane micacé. *Brochant*. Micaceous uranitic ore. *Kirwan*. Uranite. *Aikin*, *Phillips*.

(*Geological situation and Localities.*) It occurs in primitive rocks, particularly in granite. The crystals or plates are usually found in the fissures, or attached to the surface, of the accompanying minerals. In Cornwall it occurs in metallic veins, traversing granite, and is sometimes associated with the black oxide of uranium, red oxide of copper, arseniate of iron, wavellite, &c.—In Saxony, at Johanngestadt, &c. its crystals or laminæ sometimes adhere to jasper and quartz.—In Bavaria, at Bodenmais, it is associated with feldspar and beryl.—In France, near Autun, and also at St. Yrieix near Limoges, it is in veins traversing granite.

In the *United States*; In *Maryland*, it occurs near Baltimore. (GILMOR.)

2. EARTHY GREEN OXIDE OF URANIUM.* Its color is yellow of different shades, as sulphur or straw yellow, and greenish yellow. The shade of green may often be brought to view by moistening the surface; and sometimes, from accidental impurities, the yellow is mixed with a shade of brown or red.

It is sometimes in the state of a powder, forming a mere crust; and sometimes in small masses, either friable, or somewhat indurated with an earthy, imperfectly conchoidal or uneven fracture, nearly or quite dull.

(*Localities.*) It most frequently accompanies the other ores of uranium; and of course has the same localities.—In the *United States*, this variety is said to exist in *Maryland*, near Baltimore.

GENUS XXIV. COLUMBIUM.† HATCHETT.

Columbium may be extracted in the state of a white oxide from its ores; and this oxide may be reduced by a strong heat into a globule moderately hard, with a metallic lustre at its surface, and a dull grayish black fracture.

The color of its Oxide is not changed in a red heat, nor does it communicate any color to borax, when fused with it. It is nearly insoluble in the nitric, muriatic, and sulphuric acids. Its proper solvent is potash or crystallized carbonate of potash. When fused with eight times its weight of carbonate of potash, a mass is obtained, which is soluble in water. If any of the three preceding acids be added to this solution, the oxide of Columbium is precipitated, and is not redissolved by an excess of acid. But the same oxide, if not permitted to become dry, is entirely dissolved by the oxalic, citric, or tartaric acid. Tincture of galls produces an orange colored precipitate in solutions of this oxide, provided there be no excess of alkali, or of the oxalic, citric, or tartaric acid. Any excess of the three last mentioned

* Urane oxidé terreux. *Haüy*. Uran ocker. *Werner*. Hausmann. Uran ochre. *Jameson*. Pulverulent Uranite. *Aikin*. † Tantalum. *Ekeberg*.

acids should be removed by carbonate of ammonia. Indeed when the tincture of galls is poured upon this white oxide, recently obtained and still moist, an orange colored compound is also produced. (*WOLLASTON.*)

SPECIES 1. FERRUGINOUS OXIDE OF COLUMBIUM.

Tantale oxidé ferro-manganesifere. *Haüy.* Tantalit. *Ekeberg.* Hausmann. Tantale Tantalite. *Brongniart.* Prismatic Tantalium ore. *Jameson.* Columbite. *Hatchett.* Phillips. Tantalite. *Aikin.*

When recently broken, its color is dark bluish gray or nearly iron black, and sometimes brownish black. It is opaque; and its surface is sometimes chatoyant. Its streak and powder are brown or even brownish black. It gives sparks with steel; and its specific gravity appears to vary from 7.95 to 5.92.

It occurs amorphous, or in small masses about the size of a nut, which appear to be imperfect crystals, whose form is that of an oblique four-sided prism, sometimes truncated on the lateral edges, or bevelled at the extremities. Some specimens have an imperfectly foliated structure.—It breaks without difficulty; and its fracture is uneven or imperfectly conchoidal, with a lustre more or less shining, and nearly metallic.—It does not move the magnetic needle.

(*Chemical characters.*) It is infusible by the blowpipe. If this ore be reduced to powder, and fused with five times its weight of carbonate of potash and twice its weight of borax, a deep green mass is obtained, from which diluted muriatic acid extracts the iron and manganese, leaving the columbium in the state of a white oxide. A specimen from Sweden yielded Vauquelin oxide of columbium 85, of iron 12, of manganese 8. In another from *Connecticut*, Mr. Hatchett found oxide of columbium 87, of iron 21. In a Swedish specimen, Berzelius found oxide of columbium 83.2, of iron 7.2, of manganese 7.4, of tin 0.6;=98.4. In another he found oxide of columbium 66.6, of iron 10.6, of manganese 10.2, of tin 8.0, tungstic acid 5.8;=101. Another specimen from *Connecticut* yielded Wollaston oxide of columbium 80, of iron 15, of manganese 5.

(*Localities.*) The Ferruginous oxide of columbium has occurred in but few places. In Sweden, in the parish of Kemito in Finland, it is imbedded in a granitic vein, traversing gneiss. At Brodbo and Finbo, it occurs in granite.—In Germany, at Bodenmais, its structure is more distinctly foliated than usual.

In the *United States*; in *Connecticut*, near New London; but its precise situation is not known.

(*Remarks.*) It appears, that only a single specimen of this Oxide from the United States has yet been observed. This specimen was transmitted by Gov. Winthrop to Sir Hans Sloane. It was found by Mr. Hatchett in the British Museum in 1801, and enabled him to

become the first discoverer of this new metal, which he named *Columbium*. The ore itself has been called columbite.

Soon afterwards Mr. Ekeberg, a Swedish chemist, discovered the white oxide of a new metal, to which he gave the name of Tantalum. The ore, which contains it, he called tantalite.

About the year 1809, Dr. Wollaston, having obtained specimens of the Swedish ore, and a few fragments of the American specimen, instituted a series of comparative experiments. The result was, that both ores yielded white oxides perfectly similar in their most distinguishing properties. Five parts of the tantalite yielded him white oxide 4.25, oxide of iron 0.5, oxide of manganese 0.2. Five parts of the columbite afforded white oxide 4.0, oxide of iron 0.75, oxide of manganese 0.25.—Hence the identity of Columbium and Tantalum appears to be perfectly established; and the priority of Mr. Hatchett's discovery seems to claim for this new metal the name of Columbium.

Dr. Wollaston remarks, that the external surface, color and lustre of the fracture, color of the streak, and hardness are the same in the Swedish and American ores. The columbite, however, is more easily broken, its fracture is less uniform, and its specific gravity is only 5.92, while that of the tantalite is 7.95. This low specific gravity, he suggests, may arise from the state of oxidation, or from the existence of cavities.

According to a notice in vol. ii. of the Medical Repository (New Series), the American specimen from New London was found near a spring, not far from the house of Gov. Winthrop.

SPECIES 2. YTTRIOUS OXIDE OF COLUMBIUM.

Tantale oxidé Yttrifere. *Hauy*. Tantale Yttrifere. *Brongniart*. Yttertantal. *Ekeberg*. Yttrotantalite. *Brochant*. Jameson. *Aikin*. Yttertantalit. *Hausmann*. Yttrocolumbite. *Phillips*.

Its color is a dark metallic gray, or nearly iron black, and sometimes brownish black, or yellowish brown. Its powder is gray. It is opaque, or sometimes translucent at the edges. It is less hard than the preceding species, and may be scratched by a knife, though not very easily. Its structure is more or less distinctly foliated, and its masses are sometimes composed of granular distinct concretions. Its fracture is uneven or conchoidal, with a lustre more or less shining, and either metallic, or somewhat resinous. Its specific gravity is between 5.13 and 5.88. It is not magnetic.

This mineral occurs in grains, thin plates, or small masses, often about the size of a hazel nut.—It is said to occur also in four-sided prisms, either rectangular or slightly rhombic, and sometimes truncated on two of the lateral edges.

Before the blowpipe its colors become lighter, but it scarcely melts. It contains oxide of columbium 51.8, yttria 38.5, tungstic acid 2.6, lime 3.3, oxide of iron 0.5, of uranium 1.1 ;=97.8, (*BERZELIUS*.)

Its specific gravity is usually somewhat less than that of the first species, and its powder of a lighter color.—It is heavier, than the gadolinite.

This mineral is found at Ytterby in Sweden. It is imbedded in feldspar, which contains gadolinite, and is associated with quartz and mica in gneiss. Also at Finbo and Korarfvet in granite—It has also been found in Greenland by Giesecké in rectangular prisms in quartz. (*ALLAN.*)

GENUS XXV. *CERIUM.*

Cerium has scarcely been seen in a metallic state, and the characters of the pure metal are almost unknown. According to Vauquelin, there are two oxides of Cerium. The first or protoxide is white, and soluble in acids, yielding colorless or pale rose colored solutions.—The other oxide is red, and dissolves less easily in acids. In muriatic acid, however, even when cold, it is soluble with a disengagement of oxymuriatic acid gas; the solution is pale greenish yellow. (*MURRAY.*)—Both these oxides are infusible by themselves, and their fusion is not effected even by the addition of pure alkalis.—Solutions of the salts of Cerium are decomposed by the alkalis, yielding a white precipitate, which reddens, when heated. Prussiate of potash also gives a white precipitate in saturated solutions.

This metal was discovered by the Swedish chemists Hisinger and Berzelius, who gave it the name of *Cerium*, in allusion to that of the planet Ceres.

Several ores of this metal have been observed; but some of them occur in such small quantities, that their properties have been but imperfectly investigated.

SPECIES 1. SILICEOUS OXIDE OF CERIUM.

Cerium oxidé silicifere. Haüy. Cerit. Hisinger & Berzelius. Cerium Cerite. Brongniart. Cerite. Jameson. Aikin. Phillips. Cererit. Hausmann.

Its color varies from pale rose red, or flesh red, sometimes with a tinge of yellow, to brownish red or even brown. Its streak is grayish, but its fine powder is often nearly reddish gray. It is opaque, or sometimes strongly translucent. It scratches glass, and gives sparks with steel, but not easily.—It is amorphous, and has a compact or a fine grained texture; its fracture is splintery or uneven with a moderate lustre. Its specific gravity extends from 4.48 to 4.98.

(*Chemical characters.*) It is infusible by the blowpipe, although it becomes friable, and assumes a bright yellow or reddish color. With borax a globule is obtained, which is greenish, while hot, but colorless, when cold. According to Vauquelin, it contains oxide of cerium 67, silex 17, oxide of iron 2, lime 2, water and carbonic acid 12. Klaproth obtained oxide of cerium 54.5, silex 34.5, oxide of iron 3.5, lime 1.25, water 5.0;=98.75.

(*Localities.*) This ore is found in the copper mine of Bastnaes near Ridderhytta in Sweden. It is associated with pyritous copper, the sulphurets of molybdena and bismuth, mica, hornblende, &c. in gneiss.

SPECIES 2. ALLANITE. THOMSON.

Cerium oxydé silicifère noir. Lucas. Allanite. Jameson. Aikin. Phillips.

This mineral occurs massive, and in oblique four-sided prisms with angles of 117° and 63° ;—also in six-sided prisms, sometimes terminated by four-sided summits. It is brittle, and a little harder than glass. Its fracture is conchoidal with small cavities; its lustre is shining and resinous, a little metallic. It is usually opaque, even in thin fragments; and its color is brownish black. Its powder is greenish gray. Its specific gravity varies from 3.5 to 4.0.

(*Chemical characters.*) Before the blowpipe it froths, and is converted into a blackish scoria. It contains, according to Thomson, oxide of cerium 33.9, silex 35.4, lime 9.2, alumine 4.1, oxide of iron 25.4, volatile matter 4.0;=112.0.—Like the preceding species, it appears to be a siliceous oxide of cerium.

Its opacity will, in most cases, serve to distinguish it from gadolinite, of which thin fragments are translucent at the edges with a green light.

(*Localities.*) It is found in West Greenland in granite. It was there discovered by Prof. Giesecké, but first designated as a distinct species by T. Allan, esq. of Edinburgh; hence its name.—It also occurs in Sweden at Bastnaes.

(*Remarks.*) The *Cerin* of Hisinger appears to be a variety of this species. It occurs in opaque, brownish black masses, either compact or lamellar, whose specific gravity is 3.8. It melts by the blowpipe into an opaque, black globule; and contains oxide of cerium 28.19, silex 30.17, alumine 11.31, lime 9.12, oxide of iron 20.72, of copper 0.87, volatile matter 0.40;=100.78. (*HISINGER.*) It is found at Bastnaes in Sweden.

The *Orthite* of Berzelius is probably an impure variety of this species. It occurs in *straight* rays or layers; and hence its name from the Greek *ορθος*. It resembles the gadolinite in external aspect; but differs in fusibility. It contains oxide of cerium 19.50, silex 32.0, alumine 14.80, lime 7.84, oxide of iron 12.44, of manganese 3.44, yttria 3.44, water 5.36;=98.82. (*BERZELIUS.*)

It occurs at Finbo, near Fahlun in Sweden, in a vein of granite, traversing gneiss.

The *Pyrorthite* of Berzelius contains 25 per cent. of carbon, and takes fire before the blowpipe.—It is found at Korarfvat, near Fahlun.

SPECIES 3. FLUATE OF CERIUM.

This species, recently discovered by Berzelius, has occurred in very small quantities, and is but little known. It seems, however, to present

several varieties, depending on the proportions of its ingredients, or the intermixture of foreign substances.

Var. 1. NEUTRAL OF DEUTOFLUATE OF CERIUM. PHILLIPS. It occurs in six-sided prisms, or in plates, or in amorphous masses, and has a red color more or less deep.—It is nearly a pure fluuate, but sometimes contains a little yttria or thorina.

It occurs in Sweden, both at Brodbo and Finbo. At the latter place, it is found in granite, or in a rock composed of quartz, mica, and albite, and associated with emerald and yttrious oxide of columbium.

2. SUBFLUATE OF CERIUM. PHILLIPS. It is yellow, and resembles porcellanite. It contains twice as much oxide of cerium, as the preceding variety.

3. YTTRIOUS FLUATE OF CERIUM. It usually occurs in masses, not larger than a pea, and easily impressed by the nail. Its color is pale or deep red, and sometimes yellow, or white.—It also occurs in reddish brown amorphous masses, which sometimes invest gadolinite.

It is found at Finbo in Sweden.

APPENDIX TO FLUATE OF CERIUM.

1. YTTROKERITE. JAMESON. PHILLIPS.

Yttrocerit. Berzelius.

This mineral occurs in crusts, and in small amorphous masses. It has an imperfectly foliated structure, and a glistening lustre. It scratches fluuate of lime, but yields to the knife. It is opaque; and its colors are violet, grayish red, and grayish white, sometimes all mingled in the same mass. Its specific gravity is 3.45.

It is infusible by the blowpipe, but loses its color. Its fine powder is soluble in muriatic acid, forming a yellow solution. It contains, according to Berzelius, oxide of cerium 13.15, yttria 14.60, fluoric acid 24.46, lime 47.77, glucine 4.50; = 104.48.

It is found near Fahlun in Sweden, investing quartz, or disseminated in it. It also invests the pyrophysalite.

GENUS XXVI. SELENIUM.

This metal was discovered by Berzelius in the sulphur, obtained from pyrites at Fahlun in Sweden. In some of its properties it resembles sulphur—in others, tellurium. Its name is derived from the Greek, *σεληνη*, the moon.

Its color is gray with a metallic lustre. It yields to the knife, is brittle, and affords a red powder. Its specific gravity is between 4.3 and 4.6. It is a very bad conductor of caloric and electricity.

Its melting point is not far from 212°. While cooling, it may be drawn, like wax, into threads, which, by reflected light, possess a

metallic lustre; but, when viewed by transmitted light, they appear deep red. It colors the flame of the blowpipe blue, and exhales an odor, supposed to resemble that of horse radish.

No ore, of which Selenium constitutes the base, has been observed. The seleniuret of copper, and cupreous seleniuret of silver have already been described.

GENUS XXVII. *CADMIUM*.

This new metal, discovered by Stromeyer, exists in several of the ores of zinc. In color, lustre, hardness, and ductility it resembles tin. Its specific gravity is between 8.63 and 9.05.

It melts below a red heat. In air it suffers no change; but by heat is converted into a brownish yellow oxide, which is easily reduced with charcoal. Its solutions in acids yield with sulphuretted hydrogen a bright yellow precipitate; and with zinc the Cadmium falls in a metallic state.

This metal has been obtained in small quantities from the sulphuret, oxide, and carbonate of zinc.

The discovery of a new metal by Lampadius in an ore from Topshau in Hungary has been announced. The metal has received the name *Wodanium*, and the ore itself is called *Wodankies* or *Wodan Pyrites*. Stromeyer has recently examined a specimen of the same ore, but without finding any new metal. He obtained arsenic 56.20, nickel 16.24, iron 11.12, sulphur 10.71, cobalt with manganese 4.26, copper 0.74, lead 0.53; =99.80.

INTRODUCTION

TO THE

STUDY OF GEOLOGY.

Section 1. *General Remarks.*

1. **M**ODERN geology constitutes a very interesting branch of natural science. Its object is to ascertain the arrangement and mutual actions of the solid, fluid, and aeriform materials of the earth. To effect this object, it investigates the structure, position, direction, and relative situation of those large masses, beds, strata, and veins of minerals, which compose the exterior crust of this globe. Its researches extend also to the various alterations and decompositions, to which the mineral kingdom is subjected by the action of air, electricity, light, fire, and water. These changes may be gradual and slow, or violent and sudden. They are in part effected by rains, floods, tides, by lakes bursting their bounds, by the depression of land near seas, by the fall of mountains, by earthquakes, volcanic eruptions, &c.*

2. The study of geology cannot be pursued in the cabinet. It is not the structure of a single specimen nor of a whole rock, that must be observed; the examination must extend to the structure and relations of whole mountains, and even chains of mountains. This study embraces a vast number of facts, extremely diversified in their nature, complicate, and often very difficult to investigate.—Hence one source of the various geological systems, which have been proposed. Hence also, it is obvious, that numerous and extensive observations must be collected, before any general principles can be deduced and received with confidence.

The study of organic remains or fossils is essential in geological pursuits; and hence the importance of a knowledge of conchology.

3. Some of the obstacles to geological investigations arise from the interruption or mutual intersection of the strata, and from the difficulty of determining the nature of certain rocks. Others proceed from the gradual disintegration of minerals; or from the more powerful action of torrents, earthquakes, and subterraneous fires, by all which the

* See an enumeration of several important and extensive changes, produced by some of the above mentioned causes, *Jameson's Mineralogy*, v. iii. Also *Jameson's Notes on Cuvier's Essay*.

original arrangement of rocks is more or less disturbed, and their aspect changed. And it must be added, that other obstacles, often by no means the least formidable, arise from the undue influence of some favorite hypothesis, warmly, but prematurely, embraced.

4. It is not, however, to be supposed, that imperfect and premature theories are peculiar to geology. They arise from the infant state of this science, and undoubtedly tend to promote its real progress, as they necessarily produce an accumulation of facts, for the purpose of support or attack.

5. A few of the simple minerals, already described, exist in sufficient quantities to become important subjects of geological inquiry. But most of those extensive masses or strata, with which geology is concerned, are compound minerals or aggregates, composed of two or more simple minerals, mingled in various proportions, and denominated *rocks*.

6. We have seen, that a correct and useful classification, or division into species and genera, may in some good degree be effected in simple minerals. But, in regard to *rocks* or compound minerals, the case is altogether different. These rocks are composed of two or more simple minerals, united in various proportions; and, in many cases, different rocks pass into each other by insensible shades. It is hence obvious, that they cannot admit distinctions, which are strictly *specific*.

7. In some cases, when the characters of two rocks are viewed in their extremes, they appear widely different; but, when examined near the point, where they approach each other, it is sometimes almost impossible to say to which of the two a given specimen belongs. In many rocks, the different ingredients are easily distinguishable by the eye, while, in others, they are so minute and intimately combined, that they can scarcely be discerned even by the assistance of a glass.

8. Advantage may, however, be taken of the two or three predominating and most constant ingredients, or of some one ingredient, which serves as a basis for the others, to establish distinctions between these aggregates; and thus to distribute them into different *sorts* or *kinds* of rocks. This classification of rocks has been effected by Werner with as much accuracy, perhaps, as the nature of the subject permits, in regard to all those rocks, which have fallen under his observation.—There are, however, several aggregates, forming masses or strata of considerable extent, which he has not described.

Sect. 2. *General view of the Structure of the exterior crust of the Earth.*

9. Not only mountains and hills, but even the level and lowest parts of the earth, at a greater or less distance beneath the surface, contain vast masses or extensive strata of rocks. Sometimes only one kind of

rock is present. But most commonly two or more different kinds of rocks occur together, and are arranged one *over* another in a *certain order*; or rather, if the strata be highly inclined or nearly vertical, they may be said to lie one *against* another in a certain order. And it is this *order of arrangement* or alternation of different rocks, which constitutes the most interesting point of geological inquiry.

10. One of the most general facts hitherto observed indicates a division of rocks into two great classes, viz. *primary* or *primitive* and *secondary* rocks.

11. Those *rocks*, which are denominated *primitive*, have a texture more or less crystalline, are totally destitute of organic remains or petrifications, and, when both classes occur together, always lie *underneath* the secondary rocks;—and are hence supposed to have been formed before them. But although, in their *relative* situation, the primitive rocks are always *lowest*, yet, when secondary rocks are absent, the primitive often appear at the surface of the earth, and do in fact constitute the summits of the greater part of the highest mountains.—When primitive rocks are stratified, the strata are seldom horizontal; on the contrary, they are often *highly inclined*, and sometimes nearly or quite vertical. But, whether these strata were originally inclined, or whether, subsequent to their formation, they have been changed from a *horizontal* to an *inclined* position by the action of some powerful cause, is a question, on which the most distinguished geologists are divided in opinion.*

12. *Secondary rocks*, on the contrary, though sometimes found on the summits of primitive mountains, are usually placed on the declivities of these mountains, or at their feet, or under the intervening vallies or plains. Their texture, though sometimes in part crystalline, is usually more or less earthy. They are often mechanical mixtures, composed of grains or fragments of primitive rocks, united by some cement. But their secondary character is most decidedly established by the remains of animals and vegetables, which they contain. Thus marine shells appear not only in the horizontal strata of secondary rocks, but also in those, which are inclined, and placed at an elevation far above the present level of the sea. The shells are often so perfectly well preserved, that their most delicate parts may be recognised; and sometimes they constitute the greater part of certain secondary rocks.

13. In the *higher* secondary rocks, which border on primitive mountains, the strata are usually more or less *inclined*, and sometimes even vertical. But in hills of more moderate elevation, and in the lower and most level parts of the earth, the strata of secondary rocks are in general nearly or quite *horizontal*.

* See *Greenough on the First Principles of Geology*; p. 45.

14. If these *horizontal* strata be penetrated in the vicinity of the higher and *inclined* strata, the *former* will always be found *lying over* or covering the *latter*. The same fact occurs, when the examination is made in level countries at a distance from the inclined strata; but, in the latter case, it is necessary to penetrate to a much greater depth to discover the inclined or primitive strata.

15. It is hence obvious, that the *higher* and *inclined* strata *do not rest upon* the lower and horizontal strata; but, on the contrary, the *horizontal* strata are usually *placed upon the declivities* of the higher and inclined strata. For the inclined strata of the higher secondary rocks so decline as to *pass under* the horizontal strata; and the *highest* strata of primitive rocks do in fact so slope and decline, as to *pass underneath* all the secondary strata.

It is also obvious, that those rocks, which have the lowest level, when referred to the sea or the general level of the country, are of the most recent formation; for they really lie over all the other rocks.

16. It is further evident, that the *higher* the level, at which any rock appears at the surface of the earth, the *older* is that rock; for it so declines as to pass under those rocks, which appear at a lower level.—The only exception to this general fact appears in those horizontal strata of secondary rocks, which sometimes rest on the summits of high mountains.

17. Primitive rocks, whether constituting the naked summits of hills and mountains, or covered by secondary rocks, have never exhibited any organic remains of animals or vegetables.—Hence they were undoubtedly formed before the existence of organized bodies.

18. But in the higher and older secondary rocks the remains of marine animals and marine plants begin to appear. These remains are, in general, well preserved, and belong to species and even genera, which do not exist in modern seas, nor even in the more recent of the secondary rocks.

19. As the strata become newer, the shells, which existed in the older secondary rocks, gradually give place to new species and genera of shells and other marine, organic remains; and in the most recently formed strata are found species of shells, &c. perfectly resembling those, which at present exist in the ocean. Remains and impressions of vegetables, belonging to dry land, are not uncommon; and the most recent strata contain those of birds, quadrupeds, and freshwater productions.—Secondary rocks must therefore have been formed after organized bodies were greatly multiplied.

20. It should here be remarked, that some geologists have established a third class, composed of the newest of the primitive, and the oldest of the secondary rocks, to which they give the name of interme-

diate or *transition* rocks. In some of these rocks, the texture is partly crystalline, and partly earthy, and some of them contain petrifications. This class is supposed to have been formed, while the earth was *passing* from a chaotic to a habitable state; and hence the term *transition*.

21. Both the primitive and secondary classes contain several different *sorts* of rocks, distinguished by their ingredients, structure, &c. And not only do the secondary rocks always lie over the primary, but the different kinds of rocks in each class have, in general, a *determinate arrangement*, or order of superposition. The exceptions do not appear to be numerous, and may in some cases be only apparent.

22. The same rock is, indeed, sometimes repeated, as in the case of granite, gneiss, limestone, &c. It is also to be remarked, that several members in each class may be wanting, either the highest, or lowest, or an intermediate member; so that any rock may in fact appear at the surface. But the general order of arrangement in each class is so nearly the same, that, though it may occasionally be varied, it can perhaps never be said to be inverted.—In the secondary horizontal strata, a certain series or alternation of rocks is sometimes confined to a small extent; and different series occur in different countries.

23. The preceding appear to be the leading facts, hitherto observed, in regard to the structure of the exterior crust of the globe. And, although more numerous, more extensive, and deeper observations are still necessary, the following general principles appear to be satisfactorily established.

1. The minerals, which compose the external crust of the globe, from the summit of the highest mountain to the lowest point hitherto explored, must at some former period have been in a fluid state;—and the solvent must unquestionably have been caloric or water.

2. There appears to be sufficient reason for believing, that by far the greater number of minerals have been deposited from a state of solution or suspension in water;—and of course that the sea, in a more or less tranquil state, has, at some former period, for a considerable portion of time, covered the tops of the highest mountains. The distinctly crystalline structure of most of the primitive rocks, and the numerous regular crystals, which they contain, decidedly indicate a previous state of fluidity. And it seems no less certain, that this solvent must have been water.

The numerous organic remains, which exist in secondary rocks, unquestionably prove, that such rocks have been deposited from water. It is well known, that different sorts of secondary rocks have been deposited at different and successive periods. And it is equally evident, from an inspection of the organic remains in secondary rocks, that this ancient sea was *successively* peopled by different races of animals.*

* See Essay on the Theory of the Earth, by M. Cuvier; with notes by Prof. Jameson, and Prof. Mitchell.

Sect. 3. *Geological systems.*

24. It is, perhaps, universally admitted, that the *fluid agent*, employed in the formation of minerals, must have been either *water* or *caloric*. Hence two geological systems have arisen, according as the principal agency in the production of the mineral kingdom is attributed to water or caloric. Hence the *Neptunian* theory, on the one hand, and the *Vulcanian* theory, on the other. Hence the supporters of these theories are respectively called *Neptunians* and *Vulcanists*, or *Wernerians* and *Huttonians*.

Wernerian theory.

25. At some former period this globe has, for a long time, been covered with water to a greater depth, than the original altitude of the highest mountains. This immense body of water was then tranquil, or very nearly so, and contained in solution all the materials, of which the present crust of the earth is composed. In this state, chemical deposits, exhibiting more or less of a crystalline structure, were gradually made, and invested the nucleus of the globe. These chemical deposits constitute the *primitive* rocks, consisting of granite, gneiss, mica slate, granular limestone, &c. and are distinguished by their crystalline structure, and by the total absence of organic remains. During this period most of the highest mountains were formed; for their summits consist of primitive rocks.

26. But, by a gradual subsidence of the waters, the summits of the highest mountains were left naked; the tranquillity of the waters was disturbed, and currents were consequently produced. By these currents, the naked rocks would be worn and partially disintegrated; and the grains or fragments, thus produced, would be diffused through the mass of water. The rocks, formed at this period, would of course consist partly of chemical and partly of mechanical deposits. They would also lie over the primitive rocks; but, in consequence of the diminished altitude of the waters, they would appear at a *lower* level, often resting on the declivities of primitive mountains.—Many of the rocks of this period contain organic remains of marine animals and marine plants.

As organic remains make their first appearance in the rocks of this period, it is supposed, that the rocky shores, which had recently emerged from the great deep, were *passing* to a habitable state. Hence this class embraces what are called *transition* rocks, consisting of gray-wacke, some varieties of limestone, greenstone, argillite, &c.

27. But the level of the great ocean still continuing to sink, more extensive portions of the earth were left exposed to the increasing violence of the currents; and the solution, which was originally chemical, now became in a great degree composed of grains or com-

minuted fragments, detached from the older rocks.—Hence the minerals of this period consist chiefly of mechanical deposits. They lie over the two preceding classes, but still appear at a *lower* level, in consequence of the greater subsidence of the waters.—Hence also they are found near the base of high mountains, or in hills of moderate height, or in vallies, or under plains, sometimes at a great distance below the earth's surface.—This class is composed of the *secondary* or *floetz* rocks, and embraces sandstone, most varieties of compact limestone and of gypsum, chalk, basalt, some varieties of greenstone, coal, &c.

Extensive portions of the crust of the globe had now become dry ; new species and genera of animals inhabited the waters, or dwelt on the land, while numerous vegetables adorned the shores and other parts of the earth's surface. Hence the secondary rocks abound with organic remains both of animals and vegetables. Hence also the abundance of bituminous substances in this class, having proceeded from the decay of organized bodies.

28. There are a few exceptions to the general fact concerning the *low level*, at which secondary rocks usually appear ; for they sometimes rest on the summits of mountains highly elevated. Basalt and wacke are among the secondary rocks thus found. These elevated strata of secondary rocks are supposed by Werner to have been deposited during a second and sudden rise of the ocean, after it had once greatly subsided.

29. The preceding deposits of rocks are supposed to have been *universal formations*, entirely surrounding the nucleus of the earth, like the coats of an onion. But various subsequent revolutions and changes have, in many instances, destroyed or concealed the continuity of the strata. This universality in the formations of rocks is an important point in this system.

30. Two other classes of comparatively small extent, viz. alluvial deposits, and volcanic ejections, complete the series of mineral formations.

31. It is obvious, that the preceding theory recognises the general *facts*, which we have already stated (9—23) in describing the structure of the exterior crust of the globe. But, with many positions undoubtedly correct, it has interwoven others of a nature too hypothetical to be received with confidence. In some cases, it descends to a degree of minuteness in determining the arrangement and relative position of the individual rocks in the two great classes, which more recent and extensive observations have found to be inadmissible.

32. It has already been remarked (23), that there appears to be sufficient reason for believing, that most minerals have been deposited from a state of solution or suspension in water. But it is not to be supposed, that the aqueous or Neptunian theory is free from objections. Though its general outlines may be correct, we are yet unable to give

its details. It seems, however, to be rather incumbered with difficulties, than absolutely confronted by existing facts. It is obliged to admit the existence of certain operations, which cannot be repeated even on a small scale, and whose processes cannot be described.

33. Among the difficulties, which attend this theory, are the sparing solubility of most minerals in water; the inclined or even vertical position of most of the primitive, and of some of the secondary, strata; and the apparent shooting of some veins *upward* into the incumbent rock.—But our limits confine us to mere outlines, and will not permit any further prosecution of this interesting inquiry.*

Huttonian theory.

34. In the theory of Dr. Hutton, so ingeniously illustrated, but unsuccessfully supported, by Professor Playfair, *caloric* constitutes the most important agent. This theory supposes the solid parts, which form the crust of the *present* globe, to have proceeded from the disintegration and destruction of *former* continents by the gradual action of the atmosphere and water; that the ruins of those *ancient* continents were transported by water and deposited at the bottom of *ancient* seas; and that these heterogeneous materials, thus deposited, were consolidated by the action of subterraneous *fire*, and by the same agent were subsequently elevated to form the *present* continents. It further supposes, that gneiss and other stratified rocks were only softened, elevated, and sometimes variously inclined, while granite and other unstratified minerals were completely fused, and, in many cases, forced upward by this powerful agent through the incumbent strata.—Hence we find granitic summits, surrounded by gneiss, mica slate, &c.—Hence also metallic veins were filled from below by injections of melted matter.

35. By similar processes this theory provides for the disintegration and partial destruction of existing mountains and continents, and for their transportation to the bottom of present oceans, from which, by the action of subterraneous *fire*, they are again to be raised and constitute new and future continents.

36. In regard to the preceding theory we remark, that the materials, of which primitive rocks are composed, have a crystalline and uniform structure, are perfectly distinct from each other, and are frequently

* See *Jameson's Mineralogy*, vol. iii, 1st. ed.—Also *Outline of Mineralogy and Geology*, by *William Phillips*.—Also *Transactions of the (London) Geological Society*, vol. i, ii, iii, iv, v.—Also *Essai sur la Géographie Minéralogique des environs de Paris*. Par *G. Cuvier* et *Alexandre Brongniart*.—Also *Description of the Western Islands of Scotland* by *John Macculloch*.—Also *Critical Examination of the First Principles of Geology*, by *G. B. Greenough*.—Also *Geological Classification of Rocks*, comprising the *Elements of Practical Geology*, by *John Macculloch*.—Also *Memoirs of the Wernerian Society*, vol. i, ii, iii.—See also *Jameson's Manual of Mineralogy*.—*Transactions of the Royal Society of Edinburgh*—and of the *Geological Society of Cornwall*.—Also the works of *Bakewell*—*Brande*—*Bertrand*—*Brielslak*—*Cordier*—*Deluc*—*Dolomieu*—*Humboldt*—*Lametherie*—*Playfair*—*Von Buch*—*Williams*, &c. &c.

few in number. In stratified minerals there is, in general, a remarkably distinct and sudden transition from one stratum to another; and, in many cases, contiguous strata are totally unlike each other. Thus beds of shale, sandstone, limestone, coal, clay, &c. alternate with each other, and, in some cases, several times in succession. Indeed soft strata of clay are sometimes found under beds of limestone, &c. and loose sand is sometimes interposed between indurated strata.

It is sufficient to ask, could these facts exist, if minerals had been formed by the fusion of heterogeneous masses of sand and gravel, or consolidated by the injection of melted matter among loose grains of different substances promiscuously mingled? Could, for example, certain varieties of anthracite lose their bitumen by *heat*, and yet retain their pyrites, composed in part of *sulphur*?—On the contrary, the facts just stated would probably result from the formation of minerals in an aqueous fluid.

Sect. 4. *Veins*.

37. All veins appear to have once been open fissures, which have subsequently been filled by substances, that are usually more or less different from the surrounding rock.—In some cases, they have been filled by *successive* deposits of different minerals. Sometimes indeed only one mineral is present; but, most frequently, several substances occur in the same vein. Many of the saline and earthy minerals, most of the ores, and some aggregates more or less frequently occur in veins.

38. Veins, though sometimes parallel to the direction of the strata, more frequently traverse it, and may thus be distinguished from beds, which are always parallel to the contiguous strata. It has been remarked, that those veins, which occur in the vicinity of each other and contain the same minerals, are usually parallel; the fissures having probably been produced at the same time, and by the same cause.

39. In most cases, veins are much inclined to the horizon, and sometimes are almost vertical. They frequently dip in the direction of the declivity of the mountain.—It is an important character of veins, that they are often divided into several branches, which sometimes terminate in the contiguous rocks, and sometimes wind and return into the principal vein.

40. The *walls* of a vein are the rocks, contiguous to its two *sides* or *saalbandes*; and in many cases are undoubtedly the sides of the original fissure. The upper and lower sides of inclined veins are also called the *roof* and *floor* of the vein, or the *hanging* and *lying* sides.

The sides of veins, especially of metallic veins, are in general very determinate, being marked by a delicate seam, or by a layer of some indurated, argillaceous substance. In many cases, the walls of a vein

appear to have undergone some alteration, and differ more or less from the same rock at a distance from the vein. Sometimes indeed the substance of a vein is intermixed with that of the walls.

41. The breadth of veins, more particularly of metallic veins, usually lies between a few inches and a few feet. But, in some instances, veins of calcareous spar, &c. have been observed more than 100 feet in breadth.—The same vein, in different parts, often varies much in its breadth.

The length of veins, which, according to Jameson, seldom exceeds 6000 feet, may, however, vary from a few feet to several miles.

Few veins have been explored to so great a depth as that at Küttenberg, in Bohemia, where a shaft has been sunk 3000 feet. In the metallic veins of Cornwall are two or three mines about 1300 feet deep.—Many veins cease to be metalliferous at the depth of 1200 or 1500 feet.

42. The different minerals, which fill some veins, are irregularly aggregated. But it is often the case, that veins have a regular structure, being composed of a greater or less number of layers of different substances parallel to the walls. The same order or alternation of layers exists from both walls to the middle, like the leaves of a book, so opened as to form an acute angle. Thus, if quartz be contiguous to the wall on one side, it will have the same situation on the other; if sulphuret of lead be the second layer on one side, it will also be the second on the other, and so on. And further, each succeeding layer, estimating from the walls, is *impressed* by the crystals of each preceding layer.

43. Veins are of different ages; that is, some fissures were formed after others had been filled. Hence veins often intersect each other; and the *intersecting* vein is obviously the newest. Sometimes one vein either meets, or barely enters another, to which it runs parallel for a while, and then diverges at the same angle, at which it met or entered. Indeed, when one vein traverses another at a certain angle, it sometimes runs parallel on the other side, and then diverges at the same angle.

44. Sometimes the beds or strata on the opposite sides of a vein, or on its roof and floor, have the same direction, and lie in the same plane, whether inclined or horizontal. But, in other cases, the strata on the *roof* or *upper* side of the vein are *depressed* to the depth of many feet or yards below the corresponding strata on the other side. This is called a *shift* of the strata; those on one side of the vein seeming to have *slidden down*, while those on the other have retained their original position.—Sometimes also, when one vein is intersected by another, the two portions of the intersected vein, together with the rock, which contains them, are separated to the distance of several yards in a *lateral* direction.

When metallic veins are intersected by other veins not metalliferous, the latter are called *cross courses*, and sometimes very much disturb the course or direction of the metallic vein.

45. Some veins commence and terminate in the rock, in which they exist, and sometimes have no communication with the exterior surface; in some cases, indeed, the substance of the vein passes insensibly into that of its walls. By some, these veins are supposed to be of *contemporaneous* formation with the rock, which contains them. By others, they are considered a kind of secretion or filtration from the surrounding rock into cavities, produced by the drying and consequent contraction of the mass.—Indeed certain veins, which traverse the rock entirely, as veins of granite in gneiss, are by some supposed to be of contemporaneous formation with the surrounding rock.

46. Veins sometimes contain cavities from a few inches to several feet in their dimensions. These cavities, called *druses* by the miners, have their interior studded with crystals, and are sometimes filled with water.

Water-worn pebbles and even petrifications sometimes occur in veins. In Thuringia is a vein of marl, containing shells of a different kind from those in the limestone, which the vein traverses.

47. Geologists are not agreed in regard to the cause of these fissures, which now constitute veins. Some attribute them to unequal support, in different parts of the same mountain, in consequence of which the unsupported part separates and sinks; others ascribe them to the desiccation and cracking of strata; while others suppose, that the agency of earthquakes and subterraneous fire has been employed.*

Both Neptunians and Vulcanists are ready to admit, that veins were once open fissures. But while the *former* would introduce the contents of these veins from a solution of water *above*, the *latter* would inject them from a fiery furnace *beneath*.

Sect. 5. *Strata and Beds.*

48. When a single rock, or a mountain, composed of only one kind of rock, is divided by seams into parallel layers, it is said to be *stratified*, or divided into strata. But, when tabular masses of different rocks lie contiguous to each other, or when one tabular mass is contained in another rock, such masses are said to occur in *beds*. Thus beds of limestone or feldspar occur in gneiss. Beds are parallel to the strata, which contain them, are themselves often stratified, and seldom contain a great variety of minerals.—Sometimes, however, beds vary considerably in thickness from one extremity to the other.

Strata are sometimes straight, and sometimes curved or undulated; and their upper extremities, which appear at the surface of the earth, are called their *outgoings*.

In examining stratified rocks, it is important to ascertain their *dip*, or inclination to the horizon, their general direction, &c.†

* See *Werner on Veins*, tr.—Also *Greenough on the First Principles of Geology*, p. 306.

† See queries, proposed by the London Geological Society; published in *Bruce's Mineralogical Journal*, v. i, p. 43.—Also *Greenough on the First Principles of Geology*, p. 1 to 90.

Sect. 6. *Mineral Formations.*

49. The word *Formation* may signify a single mass of one kind of rock, more or less extensive, or a collection of mineral substances, formed by the same agent, under the same or similar circumstances ;— or it may convey the idea, that certain masses or collections of minerals were formed not only by the same agent, but also at the *same time*. In this latter sense, indeed, the term is almost always employed. The agent and time are to be determined by a careful examination of the external and internal relations of the whole formation.

Sect. 7. *Arrangement of Rocks.*

50. The following arrangement of Rocks and of such simple minerals, as occur in large masses, is extracted from Prof. *Jameson's Manual of Mineralogy*; Edinburgh, 1821.

CLASS I. *Primitive Rocks.*

- | | |
|---|------------------------------------|
| 1. Granite, with Sienite and
Topaz Rock. | 6. Primitive Trap.* |
| 2. Gneiss, with Whitestone. | 7. Serpentine. |
| 3. Mica Slate. | 8. Euphotide, or Diallage
Rock. |
| 4. Clay Slate. (Argillite.) | 9. Porphyry. |
| 5. Primitive Limestone, and
Gypsum. | 10. Quartz Rock. |

The first four of the preceding rocks are the most extensive and important; and in them, many of the other primitive rocks occur in *subordinate* beds.

CLASS II. *Transition Rocks.*

- | | |
|---|-------------------|
| 1. Graywacke, including transi-
tion Clay Slate. | 5. Serpentine. |
| 2. Limestone. | 6. Quartz Rock. |
| 3. Granite, and Porphyry. | 7. Red Sandstone. |
| 4. Gneiss, and Mica Slate. | 8. Trap. |
| | 9. Gypsum. |

CLASS III. *Secondary Rocks.*

- | | |
|--|---|
| 1. Sandstone, including the Coal
formation. | 3. Gypsum, including Salt. |
| 2. Limestone, including Chalk. | 4. Trap,† including secondary
Sienite. |

CLASS IV. *Alluvial Deposites.*CLASS V. *Volcanic Rocks.*

The Wernerian nomenclature of Rocks is undoubtedly susceptible both of addition and improvement. There are, in fact, a number of

* See Remarks on Trap rocks. † Among the Trap rocks are included greenstone, basalt, wacke, elinkstone, porphyry, &c.

aggregates, which have never received distinct names; but most of them, especially when connected with a short description, may be referred to some of the aforementioned rocks.

51. The following classification of rocks, founded on geological principles, has been proposed by Dr. *Macculloch*.

I. PRIMARY CLASS.

Unstratified.

GRANITE.

Stratified.

Gneiss.

Micaceous Schist.

Chlorite Schist.

Talcose Schist.

Hornblende Schist.

Actynolite Schist.

Quartz Rock.

Red Sandstone.

Argillaceous Schist.

Diallage Rock.

Limestone.

Serpentine.

Compact Feldspar.

II. SECONDARY CLASS.

Stratified.

Lowest (red) Sandstone.

Superior Sandstones.

Limestone.

Shale.

Unstratified.

Overlying (and venous) Rocks.

Pitchstone.

III. OCCASIONAL ROCKS.

Jasper.

Siliceous Schist.

Chert.

Gypsum.

Conglomerate Rocks.

Veinstones.

APPENDIX.

Volcanic Rocks.

Clay, marl, sand.

Coal.

Alluvia.

Lignite.

Peat.

Other modes of arranging rocks have been proposed; but to render them intelligible and useful would require more minute and extended explanations, than could here be inserted.—See *Essai d'une Classification Mineralogique des Roches Mélangées* par *Alexandre Brongniart*; *Journal des Mines*, No. 199, Juillet, 1813.—Also *Tableau synoptique d'oreognosie*, par *M. Tondi*; in *Lucas*, tom. ii, p. 519.

52. It has been already remarked (5), that most of the minerals, which occur in sufficient quantity to be the subject of geological investigation, are rocks or aggregates, composed of different simple minerals:

TABULAR VIEW

of the different kinds of *rocks*, described in this volume, and also of certain simple minerals again mentioned.

- | | | |
|-------------------|-----------------------|---------------------|
| 1. Granite. | 8. Trap or Horn- | 14. Topaz Rock. |
| 2. Gneiss. | blende Rocks. | 15. Graywacke. |
| 3. Mica Slate. | 9. Greenstone. | 16. Amygdaloid. |
| 4. Argillite. | 10. Hypersthene Rock. | 17. Sandstone. |
| 5. Quartz Rock. | 11. Augite Rock. | 18. Puddingstone or |
| 6. Diallage Rock. | 12. Porphyry. | Conglomerate. |
| 7. Limestone. | 13. Sienite. | 19. Breccia. |

A notice of *Alluvial Deposites* and *Volcanic Productions* will be subjoined.

1. GRANITE. KIRWAN. JAMESON.

Granit. Werner. Roche Feldspathique. Hauy. Granite. Brochant. Brongniart.

This rock is composed of *feldspar*, *quartz*, and *mica*, united to each other without the intervention of any cement. Its structure is granular; but the grains are extremely variable both in size and form, not only in different masses, but often in the same mass.

Most frequently, perhaps, the size of the grains lies between that of a pin's head and of a nut. Sometimes, however, the grains are several inches or even more than a foot in some of their dimensions, and sometimes they are so minute, that the mass resembles a sandstone, or even appears almost homogeneous to the naked eye.

The form of these grains is, in general, altogether irregular, like that of the fragments of most minerals. Sometimes the length, breadth, and thickness are nearly equal, and sometimes the length much exceeds the other dimensions. In some Granites the feldspar, or quartz, or even the mica is in crystals more or less regular.

The ingredients of Granite vary much in their proportions; but, in general, the feldspar is most abundant, and the mica is usually in the smallest proportion. Their arrangement also is various; sometimes, while the feldspar and quartz are mingled with considerable uniformity, the mica appears only in scattered masses, or is found investing grains of feldspar and quartz on all sides. In other cases, the feldspar and mica, or quartz and mica, are mingled, while the third ingredient appears in small distinct masses.

One of the ingredients of this rock, most frequently the quartz or mica, may be entirely wanting through a greater or less portion of the mass; so that specimens of true Granite sometimes contain only two ingredients.

In some Granites, quartz, or feldspar, or sometimes mica forms tabular masses of considerable extent, or even veins.

The predominant color of Granite usually depends on that of the feldspar, which may be white or gray, sometimes with a shade of red, yellow, blue, or green, and sometimes it is flesh red.—The quartz may be white, grayish white, or gray, sometimes very dark; but it is usually vitreous and translucent.—The mica may be black, brown, gray, silver white, yellowish, violet, &c.

The ingredients of Granite, though seldom in regular crystals, are in most cases very obviously the result of crystallization. The feldspar is sometimes impressed by the quartz, and sometimes also the quartz by the mica.

The simple minerals, which enter into the composition of Granite, are, in general, so intimately united, that the mass is firm and solid; but some varieties are brittle, and easily become disintegrated. The feldspar sometimes undergoes a partial decomposition, losing its lustre, hardness, and foliated structure, while, at other times, it is converted into porcelain clay.—The mica also, when exposed to the air, is subject to alteration or even decomposition.—Sulphuret of iron, which is sometimes disseminated in Granite, furnishes by its own decomposition sulphuric acid; and this acid acts upon the mica in its vicinity, thus producing a soft substance resembling steatite, and diminishing the firmness of the Granite. Indeed the beauty and utility of many Granites are sometimes almost destroyed by sulphuret of iron.—Granite, which embraces schorl, is often liable to disintegration.

Some varieties are divisible into imperfect columnar, or tabular concretions.

The specific gravity of Granite generally lies between 2.5 and 2.6; but is sometimes higher.

Granite with fine grains often embraces large grains of feldspar or quartz irregularly disseminated, or contains small masses or veins of coarse-grained Granite; and, on the contrary, Granite with coarse grains sometimes contains small irregular masses or even veins of fine-grained Granite.

Among the varieties of Granite, a few deserve particular notice.

1. GRAPHIC GRANITE.* This very beautiful variety of Granite is composed chiefly of feldspar and quartz. The feldspar is very abundant, forming a base, in which quartz under various forms lies imbedded. When this Granite is broken in a direction, perpendicular to that, in which the quartz traverses the feldspar, the surface of the fracture ordinarily presents the general aspect of *letters*, arranged in parallel lines; and hence its name. Sometimes the quartz is not arranged in any determinate order, but appears in points, triangles, imperfect crystals, &c. irregularly scattered in the feldspar. The transition from this to the common variety is often very sudden.

* Pegmatite, Hauy, Brongniart.

These letters of gray, vitreous quartz on a shining and polished tablet of white or flesh colored feldspar appear extremely beautiful.—It is principally this variety of Granite, which, by its decomposition, furnishes porcelain clay. (See Kaolin.)

This Granite is found in the Uralian Mountains, France, Portsoy in Scotland, &c.

It occurs in various parts of the *United States*, as in *Pennsylvania*.—In *New York*, near the city.—In *Connecticut*, at Litchfield, &c. It is found peculiarly beautiful in *Maine*, at Topsham, and Bowdoinham.

2. GLOBULAR GRANITE. This is composed of large, globular distinct concretions, which are sometimes several feet in diameter. These concretions are united by a kind of Granite, which is readily disintegrated, thus leaving the globular masses detached from each other.—Fine specimens of this variety occur in the island of Arran.

3. PORPHYRITIC GRANITE.* This variety is produced, when large crystals of feldspar are interspersed in a fine grained Granite.

4. PROTOGINE. *JURINE. BRONGNIART.* In this variety, the mica is replaced by talc, steatite, or chlorite; sometimes, however, a little mica is present.—It forms the summit of Mont Blanc, &c.—It is sometimes called *talcose* or *steatitic* granite.

(*Geological remarks.*) Granite is almost always a primitive rock; and perhaps never embraces any organic remains of animals or vegetables. In fact, its relative situation entitles it to the rank of the *oldest* of the primitive rocks.

This rock occurs in masses, which are often extremely large, and sometimes in veins. Sometimes also its masses appear to be stratified, presenting thick beds or strata.

But, although Granite is almost always a primitive rock, it appears to have been deposited at different periods.

When associated with other rocks, Granite is, in *most cases*, the lowest rock; hence we so often find it covered by gneiss, mica slate, &c. The oldest formations of Granite are sometimes traversed by veins of Granite, which of course are more recent, than the rock, which contains them.

Later formations of Granite are found resting on other primitive rocks, or alternating with them, as gneiss, mica slate, argillite, limestone, or in veins, traversing these rocks. These veins are sometimes insulated, and sometimes connected with masses of Granite. Indeed these veins often contain fragments of other primitive rocks. Thus veins of Granite sometimes embrace masses or detached fragments of gneiss, which are often waved or bent.

Granite sometimes repeatedly alternates with mica slate, or argillite, in the same mountain, as in the East of Ireland,

* Granite porphyroide. *Brongniart.*

Apparent veins of Granite, traversing gneiss, &c. may sometimes arise from great inequalities on the surface of the lowest formation of Granite; for these inequalities, projecting upwards, must in fact penetrate the gneiss, or other superincumbent rock, which has been deposited *upon* the Granite, and of course *around* the aforesaid inequalities.

A remarkable example of veins of Granite is said to exist at New Galloway, &c. in Cornwall, where the Granite is covered by graywacke. Portions of the Granite project into the incumbent rock, like the roots of a tree penetrating into the earth; and these granitic branches or veins are entirely surrounded by the graywacke, except at their thickest extremities, where they are united to the mass of Granite.*

Granite sometimes rests on transition rocks, or alternates with them. Examples of this arrangement occur in Scotland, 12 miles from Haddington; and in Norway, near Christiania. (*JAMESON. VON BUCH.*)

In some instances Granite is entirely covered by other rocks; but very frequently it rises into peaks, or forms the summits of mountains; and, in this case, other rocks appear at a lower level, resting on the declivities of the Granite.

Granite is a rock which exists very extensively; and, in many countries, it occurs in immense quantities. It constitutes a large portion of many of the highest mountains, of which it appears to form the central parts, as well as the summits.—It also occurs in situations comparatively low, either having never been covered by other rocks, or having been left naked by the disintegration and removal of those rocks, which once rested upon it.

Masses of Granite often present high and steep precipices. They are frequently traversed by fissures, which imbibe moisture; and hence, in consequence of the varying temperature of the weather, fragments of various sizes separate from the mass, and accumulate on the sides, or at the foot, of the mountain.

Various simple minerals are sometimes disseminated in Granite. Among these are schorl or tourmaline, garnets, emerald and beryl, pinite, chlorite, talc, steatite, topaz, hornblende and actynolite, sulphate of barytes, fluat and phosphate of lime, &c. Fine crystals of quartz, adularia, &c. are found in the cavities of Granite.—Sometimes also this rock embraces large masses or even beds of feldspar and quartz.—Indeed at Mount Perdu in the Pyrenees, according to Lapeyrouse, masses of limestone are sometimes contained in Granite, or the two minerals alternate with each other.†

Granite is sometimes traversed by veins of porphyry, greenstone, &c.

The various metals, which occur in Granite, are sometimes in beds, but more frequently in veins, or disseminated through the mass.

* Edinburgh Review, vol. xix, p. 219.

† Journal des Mines, tom. vii, No. 37.

Among the ores, thus found, are those of tin, iron, molybdena, tungsten, uranium, titanium, and sometimes those of manganese, arsenic, cobalt, zinc, lead, bismuth, copper, silver, and gold.

Blocks or boulders of Granite, sometimes many feet in diameter, are often found loose on the surface of the earth, and sometimes at a great distance from any known deposit of Granite. Various opinions have been expressed on the origin of these blocks, and the manner, in which they have been transported from their native situation.—Such blocks are found in Sweden, and on the opposite side of the Baltic, sometimes lying on chalk, sand, &c.—Also on the mountains of Jura, resting on limestone; this Granite resembles that found on some of the mountains, belonging to the group of Mont Blanc.—Similar blocks occur in the *United States*; in *Ohio*, *Vermont*, *Maine*, &c.

(*Localities.*) On this subject it is sufficient to remark, that Granite presents itself more or less abundantly in the mountains of Scotland, and Germany, the Alps, the Carpathian, Uralian, and Altain Mountains, the Andes, &c.

In the *United States* are several extensive deposits of Granite. (See *EATON'S* Index to the Geology of the Northern States, 2d edition, p. 91 to 111.)—A singular mass of Granite exists in Missouri, surrounded by transition and secondary rocks. (*SCHOOLCRAFT.*)

(*Uses.*) Granite, in most of its varieties, constitutes a very valuable, and frequently a very beautiful, building stone.

Granitic aggregates.

We have already remarked, that one of the ingredients of Granite may be wanting; and also that various simple minerals may be disseminated through Granite. Hence specimens of this rock may occur, containing only two of the ingredients of Granite, although, at the same time, three or four simple minerals may be present.

Thus we often find aggregates of feldspar and mica—quartz and feldspar—quartz, mica, and garnet—quartz, feldspar, and schorl—feldspar, mica, and hornblende—quartz, mica, schorl, and garnet, &c.

But, by *granitic aggregates*, we more particularly intend those granular compounds, consisting of two, three, or four simple minerals, among which only *one* of the essential ingredients of Granite is present.

It is true, that specimens of this kind may sometimes proceed from a real Granite; but, in many cases, they certainly belong to aggregates, forming large masses, or even whole mountains, and ought without doubt to receive distinct names.

Among the granitic aggregates, which contain only one ingredient of Granite, we mention quartz and hornblende—quartz and actynolite—feldspar and schorl—mica and hornblende—quartz, hornblende, and garnet—quartz, hornblende, and epidote—quartz and chlorite, &c. &c.

A remarkable example of an aggregate of quartz and hornblende occurs between Bodmin and Truro, in Cornwall. This aggregate, which is there called the *Roach Rocks*, covers nearly an acre of ground, and rises in steep precipices to the height of 60 feet. The quartz is predominant, and both ingredients are much crystallized.*

That, which has been called the *globular granite of Corsica*, presents itself in small oval, or globular masses, composed of concentric and alternate layers of quartz and hornblende or deep green actynolite. These globules are united by a paste, composed chiefly of the same ingredients, confusedly mingled.

In fine, granular aggregates, which contain no ingredient of Granite, and which have hitherto received no distinct name, are sometimes found, and can be made known by description only.

Mr. Kirwan has proposed for those granular aggregates, which differ from true Granite, certain *specific names*, to which, however, the names of the several ingredients must be subjoined. Thus, a compound, embracing only *two* ingredients, as quartz and schorl, he calls a *granitell*—if *three* ingredients are present, but different from those of Granite, he calls it a *granatine*—but, if there be *more than three* ingredients, he proposes the name of *granilite*.

2. GNEISS. WERNER.

Gneiss. Kirwan. Brochant. Jameson. Brongniart.

This rock, like granite, is composed of *feldspar*, *quartz*, and *mica*. But its structure is always more or less distinctly *slaty*, when viewed in the mass; although individual layers, composed chiefly of feldspar and quartz, may possess a granular structure. The layers, whether straight or curved, are frequently thick, but often vary considerably in the same specimen; and, when the mineral is broken perpendicularly to the direction of its strata, its fracture has commonly a striped aspect.

This rock, though always more or less *slaty* in its structure, is but seldom perfectly *fissile*. It however splits most easily in the direction of the strata, and especially when the separation is made in a layer of mica.

There is in Gneiss less feldspar and more mica, than in granite; but even in Gneiss the feldspar appears in many cases to be the predominant ingredient. When Gneiss is broken in the direction of the strata, the mica often seems to be more abundant, than the other ingredients; but, when seen on the cross fracture, it obviously exists in less proportion than the feldspar or quartz.

When Gneiss approaches granite, the feldspar becomes more abundant, and the structure more granular; but, when it is passing into mica slate, the feldspar diminishes, and the quartz and mica increase in quantity, and the texture becomes more *slaty*.

* Edinburgh Review, vol. xix, p. 217.

The plates or folia of mica are usually arranged parallel to the direction of the strata, and in some varieties are chiefly collected into thin parallel layers, separated by those of feldspar and quartz. The grains of feldspar are often flattened in the direction of the strata.

The feldspar is usually white or gray, sometimes with a tinge of yellow or red. The quartz is ordinarily grayish white; and the mica is often black, sometimes gray, &c.

The hardness of Gneiss is variable; and the feldspar and mica are subject to the same changes, as when they exist in granite.

1. GLANDULOUS GNEISS. This variety, in which the mica is sometimes arranged in undulated layers, presents numerous small masses of feldspar or quartz, of a globular or elliptical form, interspersed, like *glands*, through the mass. Sometimes its structure is almost granular.

(*Geological remarks.*) Gneiss, like granite, never embraces any petrifications, and is almost always a primitive rock. It, however, appears to have been deposited at different periods. Indeed, according to Jameson and Brochant, it is sometimes associated with graywacke, as in Scotland and Switzerland.

When Gneiss occurs with granite, it usually lies immediately over the granite; or, if the strata be highly inclined, it appears rather to rest against the granite, than to be incumbent upon it. Hence Gneiss is to be considered the oldest rock, next to granite. Hence also, when it thus rests on the sides of mountains of granite, its outgoing, or the level, at which it appears, is lower than that of the granite.

The more recent varieties of Gneiss sometimes alternate with other primitive rocks. They are sometimes covered by the later formations of granite; and sometimes they rest on mica slate, or even on argillite.

Gneiss is always more or less distinctly stratified, and the strata are often inclined to the horizon at a very great angle; indeed they are sometimes nearly or quite vertical. The inclination and direction of the strata often continue the same over a very considerable extent of country.

This rock, as already intimated, sometimes assumes a granular structure, and passes by imperceptible shades into granite.

In the older varieties of Gneiss, the three ingredients are often in distinct layers, which have an undulated direction.—In varieties more recent, the ingredients are more mingled;—and, when passing into mica slate, the layers become thinner, the structure more perfectly slaty, and the mass more fissile.

Mountains, composed of Gneiss, are seldom so steep as those of granite; and their summits are usually rounded.

Gneiss often contains schorl or tourmaline, garnets, hornblende, actynolite, and sometimes emerald, beryl, zircon, chrysoberyl, talc, &c. The hornblende is sometimes very abundant; and some varieties of

Gneiss gradually pass into hornblende slate or greenstone slate.—It is sometimes rendered porphyritic by feldspar.

But, in addition to the aforementioned simple minerals, scattered through the mass, Gneiss often embraces *beds* of both simple and compound minerals. Among these are beds of granular limestone, hornblende, hornblende slate, greenstone, greenstone slate, porphyry, feldspar, potstone, quartz, anthracite, &c.

Gneiss is often traversed by veins of granite.

Few of the primitive rocks are so metalliferous as Gneiss. Its ores occur both in beds and veins; but more frequently in the latter.

Gneiss, like granite, is somewhat irregular in its composition. Sometimes the mica almost entirely disappears, and is replaced by hornblende, actynolite, or chlorite slate. In some cases beds of Gneiss pass into an aggregate of feldspar, mica, and hornblende—or quartz, feldspar, and hornblende, or even greenstone slate.

(*Remarks.*) This rock exists very abundantly in many countries. Many of the more important mines of Norway, Sweden, Saxony, Bohemia, &c. occur in Gneiss.—In the district of Matura, in the southern part of the island of Ceylon, this rock contains sapphire, ruby, cat's eye, zircon, and cinnamon stone. (*DAVR.*)

In some parts of the *United States*, it is abundant.—It is a useful rock for many purposes, in consequence of the facility, with which it splits into masses of a regular form.

The *Whitestone* (Weisstein of Werner) is a finely granular feldspar, containing scales of mica and grains of quartz. It forms beds in Gneiss.

3. MICA SLATE. JAMESON.

Glimmer-Schiefer. Werner. Schiste micacé. Brochant. Daubuisson. Schistose Mica. Kirwan. Quartz micacé. Haüy. Micaschiste. Brongniart. Micaceous schistus.

Mica slate is essentially composed of mica and quartz, which are, in general, more or less intimately mingled; but sometimes the two ingredients alternate in distinct layers. Although the proportions of mica and quartz are variable, the mica usually predominates.

The quartz is most frequently grayish white; but the mica may be whitish or gray, greenish or bluish gray, brownish or yellowish gray, deep blue, or nearly black.

Its structure is always distinctly slaty, usually more so than that of gneiss; and its masses are often very fissile. The layers are sometimes straight, and sometimes undulated. Indeed undulated and straight layers sometimes alternate with each other. In some varieties the texture is very fine, and the folia of mica so small, that they are scarcely discernible by the eye, unless their aggregation be previously destroyed by heat.

This rock has often a very high lustre, when viewed by the reflected rays of the sun. It is, however, subject to decomposition, by which its aspect is much altered.

(*Geological remarks.*) Mica slate is almost always a primitive rock, and never contains any petrifications. But, like the other primitive rocks, it appears to have been formed at different periods.—In some of the older varieties, which pass into gneiss, the texture is somewhat coarse, and the mass imperfectly fissile; while, in more recent varieties, which approach very nearly to argillite, the texture become very fine, and the mass completely fissile.

When Mica slate occurs in the same mountain or district with gneiss, or with granite and gneiss, it ordinarily rests on the gneiss, or, if granite only be present, it rests upon that. This relative situation gives it the third rank, in point of age, among primitive rocks. Its strata are often highly inclined, and sometimes even vertical.

When this rock exists in the same mountain with gneiss, it appears at a lower level, than that of the gneiss; and of course it ordinarily occurs at a considerable distance from the principal summit of the mountain.—It sometimes alternates with gneiss, or other primitive rocks, or forms beds within them.

Mica slate, according to the observations of Jameson, Maclure, and Gibbs, is sometimes associated with transition rocks.

Mica slate seldom appears in high and steep cliffs, like those of granite. When it forms whole hills, the summits are usually much rounded; and the general aspect of those districts, in which this rock abounds, is often undulated, presenting long elevated ridges, separated by vallies of a moderate breadth.

The older varieties of Mica slate sometimes contain a little feld spar, and very frequently embrace garnets, among which the precious garnet is often found. Schorl or tourmaline, hornblende, staurotide, emerald, cyanite, and carbonate of lime are sometimes disseminated through this rock.

Beds of various minerals, among which are granular limestone, hornblende, hornblende slate, serpentine, quartz rock, and sulphate of lime, sometimes occur in Mica slate, or even alternate with it.

Mica slate abounds with ores, which exist both in beds and veins, but more frequently in beds. Garnets and actynolite often occur in these metallic beds.

This rock sometimes passes into quartz rock, and chlorite slate, and sometimes resembles hornblende slate, or an argillaceous slate containing hornblende.

(*Remarks.*) This rock is abundant, but less so than gneiss. It occurs more or less in several parts of the *United States*.—Many of

the Saxon, Bohemian, and Hungarian mines, and those of Delicarlia and Fahlun in Sweden are situated in Mica slate. (*JAMESON.*)

It is sometimes split into tabular masses, and employed for many common purposes.—When free from garnets and other foreign minerals, it is very difficultly fusible, and is extremely useful in constructing the hearths and sides of furnaces for melting iron, &c.

4. ARGILLITE.

Phyllade. Brongniart. Daubuisson.

Argillite has a homogeneous aspect, and is generally supposed to be a simple mineral. Some mineralogists, however, are inclined to consider it an aggregation of simple minerals in a state of very minute division. It occurs in extensive strata, and forms not only whole mountains, but even chains of mountains. Its geological relations are important, and have already been briefly mentioned, p. 448, &c.

Argillite, it will be recollected, is not always found in primitive mountains. It is sometimes associated with transition or even with secondary rocks.—When primitive, it very often rests on mica slate, but occurs at a lower level, or lies nearer to the foot of the mountain.—The oldest varieties have the strongest lustre, and alternate with beds of other primitive rocks.

In common with gneiss, Argillite contains beds of granular limestone, hornblende, greenstone, &c. and, in addition to these, it sometimes embraces beds of novaculite, chlorite slate, indurated talc, potstone, aluminous slate, graphic slate, and siliceous slate.

5. QUARTZ ROCK. *MACCULLOCH. JAMESON.*

Quarzfels. Werner. Quartzite. Brongniart & Bonnard. Quartz en Roche. Daubuisson.

This rock is usually white, sometimes more or less shaded with gray, red, yellow, blue, or purple. It sometimes presents a smooth, brilliant white surface. Its structure is sometimes granular, and sometimes compact, and its fracture splintery or scaly. Its grains or concretions are of various sizes; and in some instances it contains rounded grains of quartz of a different color from the general mass.—It sometimes contains mica or feldspar, from the latter of which it often receives a reddish hue.—In some instances it appears to be in part a mechanical deposit.

Quartz rock is often very distinctly stratified. It is found alternating with gneiss, mica slate, and argillite, into the first two of which it sometimes passes. Indeed it is sometimes associated with graywacke and amygdaloid.

It is abundant in some of the islands of Scotland, and also in Ireland.—In the *United States*, in *Massachusetts*, at Brighton, &c. near Boston, it presents various colors, and forms beds in amygdaloid. (*WEBSTER.*)

6. DIALLAGE ROCK. *MACCULLOCH. JAMESON.**Euphotide. Haüy. Brongniart.*

This rock is essentially composed of Diallage and feldspar; but it occasionally contains talc, chlorite, actynolite, mica, and quartz. Its texture is sometimes granular, like granite, and sometimes imperfectly slaty, like gneiss. The Diallage varies in its proportion to the feldspar, but is generally much less in quantity.

The Diallage has usually a crystalline structure, and sometimes presents irregular crystals in veins, traversing the rock. Its color varies from pale green to dark gray, and is sometimes purplish brown.

The feldspar is lamellar, finely granular, or compact; and its color is white or gray, sometimes with a shade of green or purple.

This rock is more or less distinctly stratified, and the strata are traversed by numerous fissures in various directions. It is often penetrated by very thin veins or laminæ of talc, chlorite, or mica, or by short irregular veins of the rock itself, in which either the Diallage or feldspar is occasionally wanting.

Diallage rock is associated with gneiss, mica slate, chlorite slate, argillite, and serpentine, with all of which it alternates.

It is found in Scotland, in the Shetland islands, particularly Balta, Fetlar, and Unst.—It is found also in Piedmont and Corsica.

7. LIMESTONE.

This very interesting mineral has already been described under the species, carbonate of lime, and its geological characters there given. We here add or repeat a few general remarks.

Limestone is found in the three great classes of rocks, primitive, transition, and secondary, but most abundantly in the last; it is also not uncommon in alluvial deposits.

Primitive Limestone has always a granular structure; but the size of the grains or granular concretions is variable, and seems in some degree to correspond with the relative age of the mineral.—Thus the Limestone, which occurs in beds in gneiss, and which, of course, is supposed to belong to the oldest formation, has usually a coarse texture, and large granular concretions. But, when its beds exist in mica slate or argillite, its texture becomes more or less fine grained, and its color is often less uniform, than in the older formations. Indeed in some of the more recent formations of primitive Limestone, the texture is so compact, that the distinct concretions can be discovered only by the glimmering lustre of the foliated fracture.

Limestone has, in but very few instances, been observed in connexion with *granite*; nor is it certain, that this granite belongs to the lowest or oldest formation of this rock.

Transition Limestone has a texture more or less compact; its colors are much variegated; and it frequently contains a greater or less number of petrifications. Its structure, however, is often somewhat crystalline; and, while it presents shining points, it sometimes contains various shells.—It sometimes rests on primitive argillite, and is associated with graywacke, and other rocks of contemporaneous formation. It often occurs on the sides, or near the foot of mountains.

As primitive and transition Limestones gradually unite, so also the latter passes by imperceptible shades into that, which is decidedly secondary.

Secondary Limestone has a compact texture, a dull fracture, and usually contains a greater or less number of shells, and sometimes other organic remains. It is always stratified; but the strata are sometimes inclined, and often horizontal. It is associated with sandstone, gypsum, marl, clay, &c.

Limestone, under the name of calcareous tufa, is often found in alluvial deposits. It is sufficiently characterized by its structure and situation, and by the vegetables, fluviatile shells, and remains of quadrupeds, which it often contains.

The term *calcareous* is applied to those beds or mountains, which are composed of *carbonate of lime*, under any of its forms.

8. TRAP, OR HORNBLENDE ROCKS.

The word *Trap* is at present employed only as a general term in *geology*. It has, however, been often used in so loose and indeterminate a sense, that it has been productive of much ambiguity and misunderstanding among mineralogists. This word is derived from the Swedish *Trappa*, which is said to signify a stair, or series of steps. It was hence originally applied to certain rocks, whose beds or strata, in consequence of the action of the weather on their edges, assumed the form of steps or stairs, and retreated in ascending.

But, without attempting to ascertain the various substances, to which the word *Trap* has been applied in different countries, and by different writers, two remarks, in regard to the present acceptation of this term, will be offered.

Mr. Kirwan, in his mineralogy, has employed the word *Trap* as the name of a *species*, which he has divided into two families, viz. common trap—and figurate trap or basalt. Both these families are described in this volume under the name of *basalt*. In fact, the two varieties, called *common* or *amorphous trap*—and *figurate* or *columnar trap*, or *basalt*, do not differ in any one important character, excepting form; they are composed of the same ingredients, and, according to Bergman, in the same proportions.

But, in modern geological inquiries, the word *Trap* is usually employed to designate a rock or aggregate, in which *hornblende* predominates. Sometimes also Trap rocks are composed of hornblende, nearly or quite pure. Hence, the *presence of hornblende*, as a predominating ingredient, characterizes those minerals, to which most geologists apply the name, *Trap*.

Trap rocks are found in primitive, transition, and secondary mountains.

In *primitive Trap*, the hornblende occurs nearly or quite pure, or is united chiefly with feldspar, forming several varieties of greenstone. But more recent formations of Trap, found among transition rocks, are contaminated by a ferruginous clay; and in some of the *secondary* traps, this blackish, indurated, ferruginous clay seems to take the place of hornblende.

Among Trap rocks may be enumerated hornblende, hornblende slate, greenstone, greenstone slate, amygdaloid, basalt, wacke, and clinkstone porphyry. To these Dr. Macculloch has added hypersthene rock, and augite rock. He also includes some varieties of sienite.*

It is hence obvious, that the word, *Trap*, is not uniformly confined to those rocks, in which hornblende predominates; but is also extended to some other rocks, which have similar geological relations to those, which are more strictly called Trap.

It is also obvious, that, although Trap may be a convenient word to designate a certain series of rocks, of which a greater or less number are often associated, it in fact conveys no definite idea of any one species or sort of rocks.

By some geologists most of the Trap rocks are supposed to be of igneous origin. (See Basalt.)

The Hornblende Schist of Macculloch also embraces those rocks, which are known by the names of hornblende rock, primitive greenstone, and greenstone slate.—The name Hornblende Rock, as employed by Eaton, in his Geology of the Northern States, includes primitive trap, sienite, greenstone porphyry, and green porphyry. The Hornblende Schist of the former, and the Hornblende Rock of the latter are usually associated with gneiss, or even alternate with it.

Greenstone, one of the most important and abundant of the Trap rocks, will be described in the next article.

9. GREENSTONE. JAMESON.

Grunstein. Werner. Brochant. Roche amphibolique. Haüy. Diabase. Brongniart.

Greenstone is essentially composed of *hornblende* and *feldspar* in the state of grains, or sometimes of small crystals. The proportions are somewhat various; but the hornblende predominates, and very

* The Pierre de Corne of the French often belongs to hornblende, or is a very fine grained greenstone.

frequently gives to this aggregate more or less of a *greenish* tinge, especially when it is moistened. Hence the name of this rock.— Sometimes the tinge of green is considerably lively, and may arise either from the hornblende, or from epidote disseminated through the mass. Sometimes also its color is dark gray, or grayish black. In fine, its color, especially at the surface, is often modified by the presence of oxide of iron.

This rock presents a considerable diversity of aspect, depending on the general structure, or on the size, proportion, disposition, and more or less intimate mixture of its constituent parts.

In some of the more common varieties, the two ingredients are in distinct grains of considerable size, like those of granite; and the foliated structure both of the hornblende and feldspar is often distinctly visible. The proportion of feldspar is sometimes very small.

From Greenstone with a coarse granular structure to those varieties, whose texture is so finely granular, that the two ingredients can scarcely be perceived, there is a gradual passage, exhibiting every intermediate step. Indeed the grains are sometimes so minute and so uniformly and intimately mingled, that the mass appears altogether homogeneous, and the different ingredients are hardly perceptible, even with a glass.— Hence the texture of this rock is sometimes distinctly crystalline, and sometimes almost compact and earthy.

Greenstone, like basalt, sometimes presents itself in *prisms* or *columns* of various sizes. These prisms may have from three to seven sides, and are sometimes as regular as those of basalt.—It also occurs in globular masses.

The general aspect of Greenstone is sometimes much diversified by the foreign ingredients, which it admits into its composition. Among these are quartz, epidote, mica, talc, carbonate of lime, and almost always sulphuret of iron, which is sometimes magnetic.—The quartz is, in some cases, abundant, and seems almost to take the place of feldspar.—Iron frequently enters into the composition of this rock. Hence, by exposure to the weather, its exterior becomes brownish or reddish brown; and some Greenstones are gradually decomposed, and converted into a reddish brown sand.

Many Greenstones are susceptible of a polish;—and that variety, which admits *epidote* into its composition, often forms a very beautiful mineral, when polished, especially if it is porphyritic. Its color is often a fine dark green, resembling serpentine. The epidote, either crystallized or compact, is sometimes in very narrow veins; and sometimes it is uniformly disseminated in very minute grains. In other cases, the epidote and feldspar form a kind of base, containing acicular crystals of hornblende; or the three ingredients are distinct, as in granite.

Var. 1. PORPHYRITIC GREENSTONE. JAMESON.* All the varieties of greenstone are occasionally rendered porphyritic by containing crystals of feldspar, which are sometimes considerably large. Crystals of quartz also are sometimes imbedded.

When these crystals of feldspar are imbedded in a blackish greenstone, whose texture is so fine, that the general aspect is homogeneous, a porphyry is produced, which appears to be one variety of the *black porphyry*† of the ancients.

OPHITE, OR GREEN PORPHYRY.‡ This is a greenstone, which to the naked eye appears homogeneous, and varies in color from blackish green to pistachio green. It contains greenish white crystals of feldspar, which on the polished surface often appear in parallelograms, and are sometimes cruciform. Its texture is very compact, and its fracture often splintery.—In many cases, its fine green color is undoubtedly produced by epidote.—This belongs to the *green porphyry* of the ancients.

Specimens of this porphyry occur in the vicinity of Boston.

(*Geological remarks.*) Greenstone occurs in beds more or less large, and sometimes forms whole mountains. It often appears in conical hills, or presents high, mural precipices, whose fronts are frequently composed of numerous columns or *prisms* of various sizes, like basalt. These columns are intersected by seams, often horizontal; and hence result those prismatic fragments, into which this rock spontaneously falls, or may easily be broken. Hence also the numerous fragments, which are usually found at the foot of such precipices.—Sometimes it forms only the summits of mountains, which are composed of rocks very different from Greenstone.

Small veins of quartz, epidote, actynolite, feldspar, prehnite, zeolite, calcareous spar, &c. often traverse Greenstone.

Beds of argillaceous iron, and of other metals are sometimes contained in this rock.

Greenstone appears among primitive, transition, and secondary rocks.

Primitive Greenstone occurs in gneiss, mica slate, and argillite; in the last of which it often forms very large beds. It frequently alternates with sienite; and is sometimes associated with compact feldspar, porphyry, &c. Its structure is often more or less distinctly crystalline, and its ingredients easily distinguishable by the eye. Sometimes also its aspect is almost homogeneous.

Transition Greenstone is associated with amygdaloid, graywacke, &c.—It sometimes occurs in globular distinct concretions, which have a lamellar structure.

Secondary Greenstone is associated with sandstone, basalt, wacke, amygdaloid, &c. It often covers wacke and basalt, into both of which

* Diabase porphyroide. Brongniart. † Variety of Melaphyre. Brongniart. ‡ Ophite, Brongniart.

it obviously passes. Its structure is sometimes so fine grained, that the distinct ingredients can scarcely be perceived. Indeed its texture is sometimes almost earthy. Sometimes also it is vesicular, or even forms the base of amygdaloid. Like transition Greenstone, it may occur in globular concretions.—It is frequently in veins, and is sometimes distinctly stratified.—In some instances this rock contains shells, or other organic remains.

(*Localities.*) Greenstone is by no means an uncommon rock in the *United States*. In *New Jersey*, it forms the summits of almost all the mountains between the western primitive Highlands and the Hudson. It is usually fine grained, and has often a dark color, resembling that of basalt. It appears to rest on sandstone, and sometimes presents mural precipices. The *Palisadoes*, near the Hudson, are precipices of Greenstone nearly 200 feet high. (*PIERCE.*)—Fine examples of *columnar* Greenstone occur in several parts of the range of secondary mountains, which extend from New Haven in *Connecticut* to Greenfield in *Massachusetts*. At Mount Holyoke, near Northampton, the columns, which are nearly perpendicular, sometimes vary in height from 60 to more than 100 feet; and are frequently *articulated*, like those of basalt. These prisms are very often hexagonal; and their diameter sometimes extends to four feet.* This deposit of Greenstone, which is more than 100 miles in length and from 3 to 25 miles in breadth, generally rests upon red sandstone.—In *Connecticut*, at Woodbury, secondary Greenstone is deposited in a basin in gneiss. (*SILLIMAN.*)—In *Massachusetts*, at Deerfield, its columns have from 3 to 6 sides, and vary in length from one foot to 30 feet; they are sometimes articulated. Most of the Greenstone near Deerfield is amygdaloidal, and often contains globular concretions of Greenstone several inches in diameter. (*HITCHCOCK.*)—Near Boston, it forms veins in graywacke or conglomerate. (*WEBSTER.*) Other examples of *columnar* Greenstone, apparently forming the summits of several mountains, sometimes from 200 to 300 feet high have been observed by J. Merrick, esq. in *Maine*, about 100 miles above Hallowell, on the Kennebec. The prisms present from 3 to 6 sides; their edges are straight and well defined; and their general aspect is that of bricks standing on their ends.—A secondary Greenstone is found also at Belfast, Jackson, Brownville, and other towns west of the Penobscot river. This Greenstone, which has hitherto been observed in detached, insulated masses, abounds with shells and impressions of shells. Some specimens much resemble graywacke slate. The same rock occurs nearly on the height of land between the Kennebec and Penobscot.—At Harpswell, in Cumberland

* See Bruce's Min. Jour. vol. i, p. 139. Also North American Review, vol. i, No. 3, p. 337.

County, is found an uncommon variety of Greenstone, through which numerous balls or spheroidal masses, apparently of *garnet*, are disseminated. These balls, of which nearly a hundred sometimes occur in a cubic foot, are easily separable from the mass, and are usually somewhat larger than bullets. This rock has not yet been observed *in situ*.

(Uses.) When this rock breaks into prismatic fragments, it forms a very useful building stone.—Most varieties of Greenstone, when heated red hot, plunged into cold water, and pulverized, become a good substitute for puzzolana in preparing water-proof mortar for the construction of wells, cellars, docks, piers, &c.

2. GREENSTONE SLATE.* JAMESON. The structure and fracture of this variety are slaty. The hornblende and feldspar, which is compact, are nearly in equal proportions. It also contains a little quartz or mica.

Greenstone slate is usually a primitive rock. Sometimes it forms large beds in argillite; and sometimes it constitutes extensive strata, or whole hills. In some instances, it contains beds of primitive limestone, or even alternates with it.

According to Jameson, the mines of Gersdorf in Saxony, and of Adelfors in Sweden are situated in this rock.

In the *United States*, extensive strata of Greenstone slate occur in *Connecticut*, a few miles westward from New Haven.

10. HYPERSTHENE ROCK. MACCULLOCH.

Hypersthene Greenstone. Jameson.

This rock is composed of Hypersthene and feldspar in various proportions. The feldspar, which is gray, greenish or purplish gray, may belong to the common, glassy, or compact variety. Its general aspect varies much, according to the size and proportions of its two ingredients. Hence this rock sometimes resembles a large grained granite, and sometimes a common greenstone. Sometimes also its structure is slaty.

It forms large beds, and is associated with trap rocks.

It is found in Scotland in the isle of Sky and in Airdnamurchan, where it was discovered by Dr. Macculloch.

11. AUGITE ROCK. MACCULLOCH.

Augite Greenstone. Jameson.

This rock is an aggregate of Augite and feldspar in variable proportions. The Augite, which is black or dark green, sometimes predominates, and sometimes the feldspar is in excess, or the two ingredients exist in nearly equal proportions. The feldspar may be compact, or glassy. The color of the rock varies from pale greenish gray to greenish black, or black, according to the proportions, size, and

* Grunstein schiefer. Werner.

intermixture of the two ingredients.—It often much resembles greenstone, with which it has been confounded.

It is found in veins and extensive masses, and has the same associations, as the other trap rocks.

It is abundant in Scotland, particularly in the Western Islands.

12. PORPHYRY.* *KIRWAN. JAMESON.*

Porphir. Werner. Porphyre. Bröchant. Brongniart.

Porphyry is a rock, presenting a compact and homogeneous basis, in which are imbedded other minerals in the form of insulated crystals, or grains. The *basis*, from which the kind of Porphyry is denominated, may be *compact feldspar*, or *claystone*, or *pitchstone*, or *clinkstone*, &c. Indeed many other minerals are sometimes *porphyritic*; but the name, Porphyry, is for the most part limited to the bases already mentioned.

The imbedded substances are most frequently *feldspar* and *quartz*, both of which are usually crystallized, the former in prisms, and the latter in pyramids. The feldspar is more common than the quartz, and may often be recognised by its oblong, quadrilateral form. Crystals of hornblende and mica also are sometimes present.

The colors of Porphyry, or rather of its bases, are considerably various; but they very frequently present some shade of red or purple, and sometimes also of brown, green, gray, and black.

The imbedded minerals are supposed to have a contemporaneous origin with the base, and not, as in some other cases, to have been deposited in preexisting cavities.

Porphyry has generally a compact texture. Sometimes, however, it is composed of tabular, columnar, or globular distinct concretions; and not unfrequently it is traversed by numerous, accidental rents and seams.

The following are some of the more common and important varieties.

Var. 1. FELDSPAR PORPHYRY.† Its base is compact feldspar. Sometimes, however, the texture of the base is a little foliated, or granular. Its fracture is somewhat conchoidal and splintery, or uneven, with little or no lustre. Its colors are reddish, brownish red, purple, greenish, black, &c. It gives fire with steel; and is susceptible of a good polish.

By exposure to the weather, the crystals of feldspar are often decomposed, and sometimes small cavities are thus produced. The base itself is also liable to decomposition, and becomes invested with a whitish crust.—This Porphyry, altered by decomposition, often resembles a volcanic product.—A polish protects it from the action of air and moisture.

* The word, *Porphyry*, is derived from the Greek, *πορφυρεα*, *purple*, in allusion to the reddish or purple color, so common in Porphyry.

† Hornstein and Felspath Porphir. *Werner.* Hornstone and Feldspar Porphyry. *Jameson.*

The base of this Porphyry has sometimes been called jasper; but its fusibility at once detects the error.

In *Massachusetts*, this variety is found in the vicinity of Boston, at Malden, Lynn, Chelsea, &c. It is associated with sienite, and petrosilex, (compact feldspar); and is sometimes equal in beauty to the best antique Porphyry. (*GODON.*) Its color is usually some shade of red, as brownish or purplish red, and sometimes it is bluish black, or greenish gray.

2. ARGILLACEOUS OR CLAYSTONE PORPHYRY.* Its base is claystone or indurated clay. It has a dull, earthy fracture; is moderately hard, and sometimes adheres to the tongue. Its colors are gray, greenish gray, brown, reddish brown, yellowish, &c.—It sometimes contains balls of a harder Porphyry, with chalcedony at their centre.—All the ingredients of this Porphyry are subject to change or decomposition; and, in this state, the mass often resembles a volcanic product.—Sometimes its masses are composed of columnar distinct concretions.

The mines of Schemnitz, &c. in Hungary are situated in argillaceous Porphyry.

There is one variety of this Porphyry, which is more earthy than common, and contains petrified branches, roots, and trunks of trees. It sometimes occurs near coal.

3. CLINKSTONE PORPHYRY.† Its basis is clinkstone. The fracture of its masses, in one direction, is generally slaty; but that of small specimens is splintery, or a little conchoidal, and nearly dull. Its hardness is such, that it gives fire with steel, but not so copiously as feldspar Porphyry.—It sometimes contains hornblende, quartz, zeolite, &c. as well as feldspar.—Its color is gray, often tinged with green, yellow, or blue, and sometimes it is blackish green, reddish brown, &c.

(*Geological remarks.*) Some Porphyries are decidedly primitive, while others belong to transition, or even secondary, rocks.

The Porphyry, whose base is compact feldspar, forms large masses, beds, or veins in granite, gneiss, and other primitive rocks. Sometimes it is found contiguous to sienite, greenstone, and graywacke.

Argillaceous Porphyry is supposed to be, in most cases, more recent, than the variety just mentioned. It lies over most of the primitive rocks; but sometimes it alternates with sienite.—In some instances, it contains chalcedony, agate, and hornstone in small masses or layers, and also opal, either in its fissures, or disseminated.

Clinkstone Porphyry is often decidedly secondary, being associated with basalt, wacke, amygdaloid, &c. It is sometimes in veins, traversing sandstone and greenstone; and sometimes it rises into insulated, conical hills.

* Clay Porphyry. *Kirwan.* Thonstein Porphir. *Werner.* Claystone Porphyry. *Jameson.*

† Porphir-schiefer. *Werner.* Porphyry-slate or Clinkstone Porphyry. *Jameson.*

(Remarks.) According to Jameson, there is an immense deposit of Porphyry, extending from Norway nearly to the Black sea.—A Porphyry, composed of fragments of feldspar Porphyry, is sometimes observed.—Some Porphyries much resemble granite.

Porphyry is, in general, susceptible of a good polish, and is manufactured into various articles both for ornament and use. Its hardness is such, that it is sometimes formed into mortars, &c.

13. SIENITE. *KIRWAN. BROCHANT. JAMESON.*

Sienit. Werner. Roche feldspathique. Haüy. Syenite. Brongniart.

This rock has often the general aspect of a granite. *Feldspar* and *hornblende* may be considered its two constant and essential ingredients; but it not unfrequently contains quartz and mica, and sometimes talc and epidote.

The feldspar is the most abundant ingredient, and the quantity of hornblende is sometimes small. It is, however, the presence of hornblende, as a constituent part, which distinguishes this rock from certain granites, that accidentally contain hornblende.

The structure of Sienite is usually granular; but the grains are sometimes coarse, and sometimes very fine. In some instances its structure is slaty.—When this rock is very fine grained, and, at the same time, contains large crystals of feldspar, it constitutes *sienitic porphyry*.

The feldspar, whose foliated texture is often very distinct, is most frequently reddish or whitish; but sometimes it receives a greenish tinge from the hornblende, or from epidote.

Sienite and greenstone are essentially composed of the same ingredients, viz. *feldspar* and *hornblende*,—and the two rocks do in fact pass into each other by insensible shades. But, in well characterized specimens of greenstone, the hornblende predominates, while in those of Sienite, the feldspar is the most abundant ingredient. It is often much more difficult to distinguish some varieties of Sienite from granite, than from greenstone.

(Geological remarks.) Sienite is sometimes found resting on granite, gneiss, mica slate, or argillite; and sometimes it is associated with greenstone, compact feldspar either simple or porphyritic, argillaceous porphyry, graywacke, &c.

Sienite is sometimes distinctly stratified. Metallic veins, containing ores of copper, silver, iron, lead, &c. sometimes traverse this rock. Some of the Hungarian mines are in Sienite.

This rock is often much altered at the surface by the action of the weather, more especially in those varieties, which contain an uncommon proportion of feldspar.

Sienite is less abundant, than most of the preceding rocks already described.

In Norway, near Christiania, it contains zircon; and, according to Von Buch, belongs to a transition formation.

In the *United States*; in *Massachusetts*, this rock is found in Weymouth, Quincy, Brighton, and other towns in the vicinity of Boston. At Malden, &c. it is intimately connected with petrosilex, either simple or porphyritic, (Compact Feldspar). At West Cambridge, &c. it is sometimes in powerful veins, traversing greenstone. Sometimes its masses are interposed in those of graywacke. (GODON.) This rock is quarried at Braintree, Weymouth, &c. and is much employed as a building stone. The Stone Chapel in Boston, the State Prison in Charlestown, and the Prison at Lechmere Point, are built with Sienite. It is sometimes employed for millstones. (J. F. & S. L. DANA.)

(Remarks.) Sienite often receives a good polish; and may be employed for the same purposes as porphyry. Its name is derived from that of *Siena*, a city of Egypt, where this rock occurs abundantly, and whence the Romans obtained it for statuary and architecture.

14. TOPAZ ROCK. JAMESON.

Topaz fels. *Werner*.

This very uncommon rock appears to be composed of fine granular quartz, prismatic schorl, and gray topaz in grains. These ingredients are arranged in alternate layers, producing a slaty structure. But the larger masses of this rock are composed of granular distinct concretions. Hence its structure is both slaty and granular. The cavities or fissures of this aggregate are often lined with regular crystals of Topaz, quartz, and schorl. Sometimes also lithomarge is present.

This rock is found near Auerbach, in Voightland, where it forms an extensive, stratified mass, resting on granite or gneiss, and covered by argillite. A similar aggregate, admitting beryl into its composition, has been observed at Mount Odontschelon, &c. in Siberia.

15. GRAYWACKE. JAMESON.

Grauwacke. *Werner*. *Brochant*. Rubble Stone. *Kirwan*. Variety of Psammite and Mimophyre. *Brongniart*. The name of this rock is pronounced Graywak-ke.

This rock is somewhat remarkable in its structure and geological relations. It is, in fact, a kind of sandstone, and is composed of grains or fragments of different minerals, but chiefly of quartz, feldspar, siliceous slate, and argillite.

These fragments are sometimes angular, and sometimes their edges and angles are rounded, thus forming nodules or globular masses. Their size is extremely variable, even in the same mass, passing from nodules one foot in diameter to grains, which are scarcely perceptible by the naked eye.

The several ingredients of this rock are united by an indurated, argillaceous substance, resembling argillite; or, what is more probable, at least in some cases, the interstices between the larger fragments are filled by the same materials, which compose the larger parts of the rock, but in grains so extremely comminuted, that they resemble a homogeneous cement;—and of these minute grains argillite may perhaps constitute a large proportion.—It sometimes contains a little mica.

This rock, although composed of substances of various colors, usually exhibits some shade of gray or brown, as bluish gray, reddish brown, &c. It is sometimes very considerably hard, and is often susceptible of a high polish.

Var. 1. GRAYWACKE SLATE. JAMESON.* In this variety the grains are so minute, that they are scarcely perceptible by the eye. The mass has an aspect nearly homogeneous, a slaty structure, and much resembles some varieties of argillite. But its gray color, its glimmering lustre, arising from scales of mica, and frequently its geological relations will serve to distinguish it from primitive argillite.

(*Geological remarks.*) Graywacke is usually arranged among the *transition* rocks, with which, or with the *latest* of the primitive rocks it is always associated. Thus it is sometimes contiguous to sienite, porphyry, greenstone, argillite, compact feldspar, and red sandstone, and is entirely destitute of organic remains. In other cases, it alternates with siliceous slate, amygdaloid, and limestone nearly or quite compact, and contains organic remains of animals and plants.—Sometimes it occurs near the foot of mountains, and sometimes at a very considerable elevation.

Graywacke is often distinctly stratified; but the strata are not usually parallel to those of the subjacent rocks. The common and slaty varieties often alternate with each other; and both are traversed by veins of quartz.

This rock is remarkably metalliferous; and its ores occur both in beds and veins, the latter of which are sometimes very large. Most of the mines of the Harz, which furnish silver and lead, are contained in Graywacke.

(*Localities.*) This rock, although less common than many of the preceding, is found abundantly in some countries, as in the Harz and other parts of Germany. In Scotland, at the Lead Hills; and indeed nearly all the mountains in that country, south of the Frith of Forth, are chiefly Graywacke. (*JAMESON.*)—It is found also near Valorsine, in the environs of Mont Blanc, and at many other places in the Alps, and is composed of fragments of primitive rocks, forming a kind of puddingstone. It there occurs at a very great elevation, forming large

* Grauwacke Schiefer. *Werner.* Grauwacke Schisteuse. *Brochant.*

masses in vertical beds. Indeed, according to the observations of Saussure, it appears to be a general fact, that, in the Alps, Vosges, and Cevennes, the primitive rocks are separated from the secondary by a kind of sandstone or puddingstone, which belongs to Graywacke.

In the *United States*, Graywacke, particularly the slaty variety, is abundant on the western side of the Alleghany mountains between the primitive and secondary strata, extending from Lake Champlain, or perhaps Canada, to the Mississippi.—In *Massachusetts*, it is one of the predominant rocks in the vicinity of Boston, in the towns of Brighton, Brookline, Roxbury, Milton, and Dorchester. It is composed of fragments and nodules, which belong chiefly to quartz, argillite, and feldspar, and which vary in size from one foot in diameter to mere grains. The spaces between the larger nodules are filled with minute grains of minerals of the same nature, as those, which compose the larger parts of the rock. It is often traversed by veins of white quartz; and sometimes it contains large masses of greenstone, sienite, argillite, or amygdaloid. At Brighton, it lies contiguous to amygdaloid. By exposure to the weather this rock is gradually decomposed, and the nodules of quartz sometimes fall out, leaving empty the cells, in which they were inclosed. This rock resembles the puddingstone of Valorsine, already mentioned; and is in Massachusetts often known by the name of *plum puddingstone*. When not decomposed, it is susceptible of a high polish. (*GODON.*) This rock is stratified, and contains veins of greenstone, composed of prismatic concretions. (*WEBSTER.*)

16. AMYGDALOID. *KIRWAN. JAMESON.*

Mandelstein. *Werner.* Roche Amygdaloide. *Brochant.* Amygdaloide. *Brongniart.*

Amygdaloid is a compound rock, composed of a basis, in which are imbedded various simple minerals. But these imbedded minerals are not crystals and grains, apparently of contemporaneous origin with the basis itself, *as in the case of porphyry*. On the contrary, their form, though sometimes irregular, is usually spheroidal or oval, like that of an *almond*; and hence the *name** of this rock.

The *basis* of this rock is usually more or less argillaceous, and may be wacke, fine grained greenstone, basalt, indurated ferruginous clay, or some other rock belonging to the trap formation. Its color is commonly some shade of gray or brown, as greenish or brownish gray, reddish brown, &c. Its hardness is sometimes moderate, and sometimes enables it to give sparks with steel. Sometimes the base is a little stratified; and sometimes the rock presents columnar or globular distinct concretions.

The *imbedded* substances are calcareous spar, quartz, chalcedony, agate, epidote, steatite, lithomarge, green earth, chlorite, zeolite, hornblende, feldspar, sulphate of barytes, &c.

* From the Latin, *amygdala*, an *almond*.

Hence the general aspect of this rock is that of a basis, which once contained cavities or vesicles, that have subsequently been filled, either entirely or in part, by the minerals, which now appear imbedded. Sometimes these imbedded minerals are easily separable. Sometimes the cavities are only in part filled, their interior being lined with a crust;—and sometimes they are entirely empty, in consequence, at least in many cases, of the decomposition of the once imbedded minerals.—In general, only one substance is imbedded in the same cavity; but sometimes two or three minerals are united in the same nodule, one being contained within another. Some of the nodules have a cavity at the centre, lined by minute crystals of quartz and epidote.

Sometimes the base undergoes decomposition, while the quartz, epidote, or other imbedded substance remains, projecting above the surface. This rock is then often called a *Variolite*;^{*} but other aggregates have received the same name.

Some Amygdaloids, in consequence of their vesicular structure and a partial decomposition, resemble lava.

Var. 1. TOADSTONE. The name of this variety of Amygdaloid is suggested by the general aspect of the rock, which somewhat resembles the exterior of a *toad*.

(*Geological remarks.*) Amygdaloid is sometimes found contiguous to greenstone and sienite, or resting on graywacke, or alternating with compact limestone. In such cases, it must belong to the transition class, or to the latest of the primitive rocks.—In other cases, it is associated with wacke, sandstone and other rocks of recent formation. It is sometimes traversed by veins of quartz and feldspar.

(*Localities.*) Amygdaloid, though not very common, is abundant in some countries, as in the Harz, Derbyshire, &c.

The toadstone of Derbyshire deserves particular notice.—Its ordinary colors are brownish gray, purplish brown, bluish, or greenish; and its vesicles are either empty, or filled with white or greenish carbonate of lime. The lowest bed of *toadstone*, which is sometimes 80 yards thick, rests on a very thick bed of stratified *limestone*, containing ammonites, &c. and some ores in its veins.—This bed of toadstone is also covered by a bed of compact *limestone*, which contains numerous veins of the sulphurets of lead and zinc, calamine, &c. also fetid carbonate of lime, nodules of hornstone, and numerous organic remains. And it is a remarkable fact, that the metallic veins which traverse both these beds of limestone, have rarely penetrated the toadstone. A number of rents, which proceed from the limestone into the upper and lower sides of the bed of toadstone, contain sulphuret of lead, &c.—Over the second bed of limestone, already mentioned,

^{*} This term is derived from the Latin, *variola*, *small pox*, in allusion to the spotted aspect of the mineral.

are found *two* beds of toadstone, and *two* of limestone, alternating with each other.—The limestone, which is the highest of these *four* beds, contains elastic bitumen; and is itself covered by a thick bed of *shale*, which embraces beds of sandstone, limestone, clay, &c. and presents some vegetable impressions.—The shale is covered by a thick deposit of *sandstone*, which exhibits impressions of reeds, flags, &c. and, in the upper part, becomes softer and micaceous.—Over this sandstone are placed 18 beds of *sandstone* and *shale*, constituting the Independent coal formation of Werner.* (*FARET*, in Nicholson's Journ. vol. xxxv.)

In the *United States*, several varieties of Amygdaloid are found in *Maryland*, &c. on the Blue Ridge.—In one variety, the base is brown, has a texture like that of petrosilex (compact feldspar), gives fire with steel, and contains spheroidal masses about the size of an ounce ball, of a ferruginous aspect, and easily separable from the base.—In another variety, the base is gray, brown, and greenish gray, and contains small greenish masses, which appear to be epidote. This base is subject to decomposition, leaving the imbedded substance projecting above the surface, and constituting a *variolite*.—In a third variety, the imbedded substance is white, and liable to decomposition, thus rendering the base vesicular.—The last two varieties belong to transition rocks. (*HARDEN*.)—In *Massachusetts*, at Mount Holyoke, a variety of Amygdaloid is found, which resembles the toadstone of Derbyshire.—At Brighton, near Boston, an Amygdaloid is found contiguous to sienite and greenstone, and sometimes it rests on graywacke. Its base is commonly reddish brown; and the imbedded nodules are quartz, feldspar, carbonate of lime, epidote, &c. Some of the nodules of quartz appear as if enchased in epidote. This rock, which has sometimes a slaty texture, and even exhales an argillaceous odor, when moistened, is analogous to the toadstone of the English. (*GODON*.)

17. SANDSTONE. JAMESON.

Sandstein. Werner. Grés. Haüy. Brochant. The Psammite of Brongniart contains several varieties of Sandstone. Some varieties are called Freestone.

Sandstone is, in most cases, composed chiefly of grains of quartz, united by a cement, which is never very abundant, and often, indeed, is nearly or quite invisible. These grains are sometimes scarcely distinguishable by the naked eye, and sometimes their magnitude is equal to that of a nut or an egg, as in those coarse sandstones, called *conglomerate*, and sometimes puddingstone or breccia.

The cement is variable in quantity, and may be calcareous or marly, argillaceous, or argillo-ferruginous, or even siliceous. When siliceous, the mineral often much resembles quartz.

* For several interesting details in regard to secondary rocks, consult *Essai sur la Géographie Minéralogique des environs de Paris*; par Cuvier et Brongniart.—Also *Transactions of the Geological Society*, London, vol. ii, on the chalk basins of the Isle of Wight and of London. See also *Outline of Mineralogy and Geology*, by William Phillips.

The texture of some Sandstones is very close, while that of others is so loose and porous, as to permit the passage of water. Sometimes, indeed, this rock is vesicular.

Some varieties are sufficiently solid to give fire with steel, while others are friable, and may be reduced to powder even by the fingers; but this powder discovers the hardness of quartz by the ease, with which it scratches glass or steel. Sandstones with a marly cement are often very friable.

Its fracture is always granular or earthy, although, in some instances, it may, at the same time, be also conchoidal or splintery. Some Sandstones have a slaty structure, arising from scattered and insulated plates of mica, and have been called *Sandstone slate*.

Its most common color is gray or grayish white, sometimes with a shade of yellow, brown, or green, and sometimes it is reddish or reddish brown, &c. In some cases, the color is uniform; in others, it is variegated.

In addition to quartz, some Sandstones embrace grains of feldspar, flint, and siliceous slate, or plates of mica. The mica is sometimes in considerable quantities in those friable sandstones, which accompany coal.

Some Sandstones are so ferruginous, as to form a valuable ore of iron, containing either an oxide or the carbonate of iron.

Some varieties of this rock deserve particular notice.

*Var. 1. RED SANDSTONE.** The grains of this variety are usually coarse, and united by an argillaceous cement, which is at the same time ferruginous; hence the dark reddish or reddish brown color, which it presents.—It sometimes contains scales of mica, or embraces petrified wood. Fossil bones have also been observed in it.—It is abundant in many countries; and by the miners is sometimes called *Red Dead Lier*.

2. VARIEGATED SANDSTONE.† JAMESON. This Sandstone presents a diversity of colors, as yellow, green, brown, red, and white, which are usually arranged in stripes, or zones, either straight or winding. It has commonly a close texture and fine grain; but it very often embraces oval or rounded masses of clay. These argillaceous masses, called *stone-galls* or *clay-galls* by workmen, often fall out, when exposed to the weather, and much diminish the value of this variety for the purposes of architecture. Its cement is usually argillaceous.

3. WHITE SANDSTONE.‡ This includes many of the more common and valuable varieties of Sandstone. Its color is whitish gray, or gray, and generally uniform; but sometimes is accidentally marked with yellowish, reddish, or brownish spots, &c. It is sometimes solid and

* Rother Sandstein. *Werner*. Grés rouge. *Brongniart*.

† Bunter Sandstein. *Werner*. Grés bigarré. *Brochant*. *Brongniart*. ‡ Grés blanc. *Brongniart*.

firm, and sometimes friable even between the fingers. Its cement is often calcareous.—This variety, which seldom contains clay-galls, is well adapted for various uses in the arts.

4. FLEXIBLE SANDSTONE.* This rare variety, though friable, has a slaty texture, and is flexible, but not elastic. If a plate or layer of this Sandstone be held horizontally, it bends by its own weight. Its flexibility is attributed to the presence of grains of quartz so flattened and elongated, that they resemble plates of mica.—This variety is found at Villa-Ricca, in Brazil.

5. QUARTZY SANDSTONE.† Its texture is very fine and close, and its fracture conchoidal with some lustre. Its granular structure, however, is perceptible in consequence of its translucency.—It much resembles some varieties of quartz.

A variety of Sandstone (*Grès pulvisculaire* of Haüy), occurring in Turkey, is composed of very minute grains, has a close texture, a splintery fracture, and does not appear granular, until the rock has been exposed to the action of fire. It hardens in oil.

(*Geological remarks.*) Sandstone, although most decidedly a secondary rock, has been formed at different periods, under different circumstances, and is hence associated with different rocks.

The coarse *red* Sandstone is sometimes found associated with graywacke, or even resting on primitive rocks. Sometimes also it is covered by bituminous marlite, compact limestone, greenstone, &c. It must therefore belong to the older and lower deposits of this rock.

Some mineralogists arrange the old red Sandstone with transition rocks. Indeed Dr. Macculloch has given the epithet of *primary* to a red Sandstone, which alternates with gneiss and quartz rock, and into both of which it passes. It is remarked by Macculloch, that whether we view this rock as Sandstone or quartz rock, it must be considered a primary rock possessing a mechanical structure.

Red Sandstone is sometimes connected with coal; and, according to Von Buch, large beds of coal, in Silesia, are embraced in this rock.

Some red Sandstones belong to formations, which are evidently more recent, than that, which is usually called the *old* red Sandstone, and lie above coal.

The *variegated* Sandstone appears to be a later deposit, than the preceding. It sometimes *rests* on gypsum, and is *covered* by shell limestone. Sometimes also it rests on magnesian limestone, and is covered by oolite. Sometimes it contains beds of oolite and Sandstone slate.—It is abundant in England, and some parts of Germany.

The green Sandstone or sand of England rests on oolite, and is covered by the chalk formation. (JAMESON.)

* Grès flexible. Brongniart.

† Grès lustré. Haüy, Brongniart.

Other formations of Sandstone are still more recent. Thus in the vicinity of Paris, Sandstone is found above a deposit of gypsum, which is obviously of later formation, than the gypsum, on which the variegated Sandstone rests.

Sandstone is, in general, more or less distinctly stratified. Its beds are very often nearly or quite horizontal; but sometimes, especially in the older varieties, they are much inclined or even vertical. Sometimes also, when in the vicinity of primitive mountains, its beds are thin, and much bent or waved.—Beds of Sandstone are sometimes intersected by fissures perpendicular to the direction of the strata, and hence fall into tabular masses, which are often very large.

In addition to beds of oolite and compact limestone, Sandstone sometimes embraces thin beds of coal, distinct from those, which may be said to constitute a coal formation. Some Sandstones, which appear to belong to the older varieties, are traversed by veins of quartz.

Sandstone is sometimes found near the summits of mountains highly elevated; but more frequently its beds appear in level countries, or constitute hills of a moderate altitude, but with a rapid ascent.

Those countries, in which Sandstone abounds, often present many interesting and impressive views. Sometimes its beds seem to have been broken into large tabular masses, which are promiscuously scattered, or heaped on each other in wild disorder.—Sometimes it rises in a series of high pillars, or of conical hills, high and acute, and placed at only a small distance from each other. The summits of these hills and pillars are often nearly at the same level, and the seams, which separate the strata, correspond through the whole series. It is hence highly probable, that such a series of hills or pillars once constituted a continuous mass, traversed by perpendicular fissures; and that subsequent alterations have arisen from the action of the atmosphere and water. A striking example exists at Adersbach in Bohemia, where these cones and pillars of Sandstone, sometimes insulated, and sometimes united at their bases, rise to the height of 200 or 300 feet.—Insulated masses of Sandstone sometimes remain in the midst of banks of sand.

Sandstone, more particularly in the older formations, sometimes contains metallic substances, disseminated through the mass, or in beds, or in veins. Among these are the sulphurets of iron, mercury, lead, and copper, pyritous copper, and arsenical cobalt.

Various organic remains occur in Sandstone, among which are reeds, impressions of leaves, trunks of trees, and shells, both fluviatile and marine. Sometimes the wood is scarcely altered.—Sometimes also fossil bones occur in Sandstone.

(*Localities.*) In New Brunswick, at Cape Maraguin, Grindstone island, and Pidroa river, is found a variety of Sandstone which is much employed for grindstones. It alternates with puddingstone, into which it passes. (*THAYER.*)

In the *United States*, Sandstone is abundant in various parts. A deposit of *red* Sandstone, which appears to belong to the older formations of this rock, extends, with a few interruptions, from Connecticut river to the Rappahannock, a distance of about 400 miles; its average breadth is between 15 and 25 miles. It is sometimes covered by beds of greenstone, wacke, &c. (*MACLURE.*)—In *North Carolina*, between Chapel Hill and Raleigh, has been recently observed an extensive deposit of gray and red Sandstone, which is probably a continuation of the same formation from the Rappahannock. (*OLMSTEAD.*)—In *Ohio*, are extensive deposits of Sandstone; it sometimes contains fossil fish, and abounds with vegetable remains. Its structure is sometimes slaty. (*ATWATER.*) In some parts of Ohio, Tennessee, and Virginia, it is so ferruginous, that it is employed as an ore of iron. A singular deposit of Sandstone is found on the *summit* of the South Mountain or Blue Ridge, 8 or 10 miles east from Hagarstown, in Washington County, *Maryland*. It occupies an extent of about 4 or 5 miles in length by about half a mile in breadth, and is there called the *black rocks*, in consequence of being covered with a dark brown lichen. This Sandstone does not present itself in regular stratified beds, but in tables or large masses, which seem to have been rent from their original bed by some powerful concussion, and thrown promiscuously together in wild confusion.—Its masses are variable in size; but some of them weigh several hundred tons. They discover no marks of alteration or disintegration.—This Sandstone does not contain plates of mica, and is destitute of stratification; but the veins of crystallized quartz, which traverse it, and some other circumstances seem to indicate, that it belongs to the oldest formations of this rock.—Limestone and slate probably constitute the base of this mountain. (*HARDEN.*)—In *New York*, at Blenheim, a Sandstone, which alternates with graywacke slate, is quarried for grindstones. (*BECK & EATON.*)—A deposit of *red* Sandstone, more than 100 miles long, extends from New Haven nearly to the State of Vermont, intersecting the States of *Connecticut* and *Massachusetts*. It is from 3 to 25 miles wide, and is bounded by the primitive on both sides. Bones of an animal, considerably large, have recently been found in this Sandstone 18 feet below the surface of the rock. (*SILLIMAN. SMITH.*)

(*Uses and Remarks.*) Sandstone in some of its varieties is very useful in the arts, and is often known by the name of *Free-stone*.

When sufficiently solid, it is employed as a building stone. In most cases, it may be cut equally well in all directions; but some varieties naturally divide into prismatic masses.—Some varieties are used as millstones for grinding meal, or for wearing down other minerals, preparatory to a polish. These stones, while rapidly revolving, sometimes burst with a loud and dangerous explosion. This phenomenon occurred no less than four times, in the course of forty years, in the millstones, employed at Oberstein for grinding agates; they were red Sandstone. The same accident has taken place in grinding meal.—When the texture is sufficiently loose and porous, Sandstone is employed for filtering water. Some varieties are used for whetstones.

Some Sandstones absorb moisture, and, by exposure to the changes of the atmosphere, are gradually disintegrated; others become more solid by such exposure.

18. PUDDINGSTONE, OR CONGLOMERATE.

Le Poudingue. Brochant. Brongniart.

This rock is only a very coarse sandstone. It is composed of siliceous pebbles of quartz, flint, siliceous slate, &c. united by a cement, which is usually siliceous, sometimes both siliceous and ferruginous, and sometimes a little argillaceous. These pebbles vary in size from that of a pea to that of an egg. Their form is ordinarily rounded or oval; and it is, in fact, chiefly by the more or less rounded form of these pebbles, that Puddingstone is distinguished from a breccia.

This rock is found in various situations relative to other rocks, and has been formed at very different periods. It is sometimes associated with red sandstone.

It is sometimes employed for millstones; and some varieties receive a good polish.—The term *Conglomerate* is sometimes applied to Puddingstone, as well as to the less coarse varieties of sandstone.

Conglomerated Rocks. The term *Conglomerate* has been variously applied by different geologists. While some have confined it to certain coarse sandstones or Puddingstone, others have included the various breccias, and also certain varieties of graywacke, the last of which is indeed a kind of coarse sandstone.

It is obvious, from the nature of conglomerated rocks, that their ingredients and general aspect must be extremely variable.—Many conglomerates consist of fragments of primitive or transition rocks, partly rounded, and partly angular, united by some basis. Hence the expressions trap or greenstone conglomerate, limestone conglomerate, &c.—Conglomerated rocks sometimes form inclined strata.

It is obvious, that all true conglomerates must be composed of fragments of previously existing rocks, in regard to which they must

be of secondary formation. They have, however, been formed at very different periods.—Some rocks, according to Jameson, which have the aspect of conglomerates, cannot be considered mechanical deposits; for the apparent fragments, of which they are composed, are not rounded, nor do they present distinctly fractured surfaces, but, on the contrary, gradually pass into the base.

19. BRECCIA.

Breche. Brongniart.

A Breccia is an aggregate, composed of *angular* fragments of the same mineral or of different minerals, united by some cement. Sometimes, however, a few of the fragments are a little rounded. The different fragments almost always present a variety of colors.—Some Breccias are traversed by metallic veins.

Var. 1. SILICEOUS BRECCIA. This may consist of fragments of agate or of jasper, differently colored—or of fragments of flint and jasper—or of quartz, flint, siliceous slate, &c. united by a siliceous cement. Sometimes the cement itself appears to be quartz, jasper, or flint.—It often receives a good polish.

2. CALCAREOUS BRECCIA. This is composed of fragments of limestone or marble, united by a calcareous cement.

The *Nagelfluh* of some mineralogists is a Breccia, composed chiefly of fragments of limestone, sometimes with rounded pebbles of quartz, united by a calcareous cement. It sometimes forms large beds near the foot of calcareous mountains.

Calcareous Breccia frequently receives a high polish, and is employed in works of ornament. (See Potowmac Breccia Marble, p. 158.)

*3. TRAP BRECCIA.** This is composed of fragments of basalt, amygdaloid, hornblende, and sandstone, cemented by an argillaceous basis, which appears to be decomposed basalt, greenstone, or wacke. The fragments, extremely variable in size, are sometimes very large.

This Breccia occurs in beds, usually horizontal, varying in thickness from a few inches to many yards, and sometimes alternating with basalt.

This rock constitutes a considerable portion of Arthur's Seat, near Edinburgh, where it rests on inclined strata of rocks, belonging to the oldest coal formation. (*JAMESON.*)

ALLUVIAL DEPOSITES.

Those beds of clay, sand, gravel, pebbles, &c. which constitute so large a portion of the earth's surface, are called *Alluvial Deposites*. These substances, which originally proceeded from the disintegration of rocks and simple minerals by the action of the atmosphere and water, have been subsequently transported by *water*, and deposited in nearly

* Trap Tuff, Jameson.

horizontal beds in vallies, or on plains, or on the beds of rivers, or on the margin of seas. Hence they occur not only near the level of the sea, but also in hollows or on plains highly elevated in mountainous countries.

All these Alluvial Deposites are comparatively of recent formation. Many of them have been formed within the memory of man; and others have appeared, or are still daily forming, under our own observation.—They are peculiarly interesting in geological inquiries, being indicative of important changes, produced on the surface of the earth. Indeed, in the examination of alluvial earths, the farmer is in no small degree interested; and not unfrequently the miner finds their contents highly valuable.

The more common Alluvial Deposites are gravel, sand, clay, loam, peat, bog iron ore, and calcareous tufa or incrustations. These substances are often much mixed with decayed vegetable matter.

Beds of gravel and sand, when in the vicinity of mountains or connected with them by rivers, sometimes contain grains or fragments of native gold, oxide of tin, or magnetic iron in sufficient quantities to be explored with advantage. It has already been remarked, that much of the gold of commerce proceeds from alluvial earths.—In a branch of Falmouth harbor, England, a shaft was sunk 50 feet through a bed of alluvial matter, which had proceeded from the disintegration of granite; and at the bottom was found a bed, from two to ten feet in thickness, composed of rounded masses of the oxide of tin. The profit of this undertaking was at least £50,000. (*PHILLIPS.*)

In addition to these *ores*, the sapphire, ruby, chrysolite, hyacinth, diamond, &c. having by their hardness been enabled in a great degree to resist attrition, while carried by the waters from their original situations, constitute no small part of the riches of Alluvial Deposites.

Beds of sand sometimes contain ferruginous clay, which operates as a cement; and a friable sandstone is thus gradually produced.—It ought also to be remarked, that important changes in the face of a country are often produced by the action of wind on deposits of loose and fine sand.

Numerous organic remains occur in Alluvial Deposites. Large beds of bituminous wood, and even trunks of trees, in which the wood is very little altered, are sometimes found, and seem to constitute a subterraneous forest.—Among animal remains are shells of oysters and muscles, teeth of sharks, and the bones of the horse, ox, stag, elk, elephant, &c. Some of these animals belong to extinct species, while others resemble those now living.

The North of Europe from Holland through Prussia, Pomerania, &c. to Russia—and the southeastern coast of the *United States* from New York to Florida, and thence to the Mississippi, furnish interesting examples of Alluvial Deposites.

VOLCANIC PRODUCTIONS.*

Many parts of the external crust of this Earth are subject to the action of subterraneous fires. In some cases, these fires are comparatively mild, and produce no important effects, excepting the destruction of the combustible, which feeds them, and a slight alteration of the contiguous earths and stones. These are often called Pseudo-volcanoes; and are nothing more than coal mines in a state of combustion.

But, in other cases, these subterraneous fires rage with resistless impetuosity, produce important changes in the minerals, which cover or surround them, and eventually burst through the incumbent crust of the Earth; thus constituting a true volcano.—From the mouth or crater of the volcano, thus produced, are ejected various substances, some of which are perfectly unchanged by the fire; some are partially changed; and others are more or less completely *fused*, and converted into lava, scoria, glass, &c.

But, notwithstanding volcanoes are confined to a few points on the Earth's surface, very important changes have been produced in their vicinity; and many whole islands have been brought into existence by submarine volcanoes.†

Few questions have produced more collision among mineralogists, than that, which regards the proper application of the term *lava*. This word, according to Kirwan, is derived from the Gothic, *lopa* or *lauffen*, to run, and is applied to the melted or liquefied matter, discharged from the mouths of volcanoes.

It seems highly probable, at the first view, that large masses of rocks, which had been subjected to the action of volcanic fire, and which had been so melted as to *flow*, would retain distinct and evident indications of their fusion. But, whatever may be the fact, the two extremes, at which different mineralogists stand in the use of the word lava, are widely distant. While some confine this term to certain substances, more or less porous or tumefied, others extend it to such minerals as basalt, wacke, pitchstone, obsidian, and some varieties of compact feldspar, amygdaloid, porphyry, &c.—It will be sufficient here to remark, that every rock, found in volcanic mountains, must not, *for that reason only*, be pronounced lava, especially if it exhibits very few, or even no internal marks of previous fusion.

As real volcanic productions are merely *alterations* of other minerals, they cannot, strictly speaking, constitute distinct species. They must, on the contrary, exhibit a great diversity of external

* In preparing this article on volcanic productions, the opinions of Dolomieu, Spallanzani, Faujas, Kirwan, and others have been consulted.

† According to Jameson, about 193 active volcanoes have been observed; of which 13 belong to Europe and its islands—66 to Asia and its islands—8 to the islands of Africa—and 106 to America and its islands.

aspect and chemical composition, according to the nature of the *original* substances, the degree of heat, and the consequent calcination, fusion, tumefaction, or vitrification. Hence the different products of volcanic fire pass into each other. The lava, which Dolomieu examined, yielded silex 40 to 60, magnesia 3 to 16, lime 1 to 5, iron 6 to 25.

Lava, scoria, enamel, and glass comprise by far the most important and interesting volcanic productions; but all those substances, which have been actually *ejected*, although they may have suffered little or no alteration by volcanic fire, deserve attention.—The following arrangement will therefore be observed.

1. Ejected substances, more or less modified by volcanic fire.
2. Substances, ejected without alteration.
3. Substances, sublimed by volcanic fire.
4. Alterations in volcanic productions, after ejection.
5. Pseudovolcanic productions.

1. *Substances, more or less modified by volcanic fire.*

1. *Compact Lava.* It is very certain, that some real lavas are much more compact than others; that is, they contain fewer and smaller pores or cavities. Thus the lower parts of a current of lava, being subjected to the pressure of the incumbent mass, may possess pores too minute for the naked eye to perceive, or may, *for a small extent*, be altogether compact;—and such lava will more or less resemble the original stone.

It is, however, very difficult to admit the existence of *entire* currents of lava, uniformly solid and compact through the whole mass, entirely destitute of every *internal* mark of fusion, and even containing in their interior the impressions of leaves.—It will be understood, that these remarks are confined to those currents, which are supposed to have flowed on the surface of the earth; and of course do not extend to the lava, which may have been produced by submarine volcanoes, under the immense pressure of the incumbent mass of water and earth.

M. Dolomieu enumerates four kinds of compact lava.—The first has for its base an argillo-ferruginous rock; and comprehends basalt, and some varieties of wacke, greenstone, amygdaloid, siliceous slate, and hornblende in mass.—The second has a petrosiliceous base, and comprehends some varieties of pitchstone, compact feldspar, &c. Both the preceding contain crystals or grains of feldspar, augite, hornblende, mica, leucite, &c.—The base of the third kind is feldspar or granite—and that of the fourth is leucite.

It is worthy of notice, that Dolomieu has remarked, that *compact* lavas are much more common in the vicinity of ancient and *extinct* volcanoes, than in the currents of those, which are now active, and

whose real products may of course be ascertained. Indeed Gioeni says that *modern* volcanoes seem to have lost their power of producing perfectly compact lava.

Local circumstances are often extremely important in determining the existence of volcanic productions; for several minerals are known to be susceptible of certain alterations, by which they become porous, &c. and strongly resemble those substances, which have been ejected from volcanoes. This is sometimes the case with amygdaloid, wacke, porphyry, serpentine, greenstone, hornblende, and argillite in a decaying state.

On the other hand, it should be remembered, that the characters of true lava are much altered by long exposure to the action of air and moisture; its asperities are worn off, and its pores or cavities more or less filled by the filtration of other substances.

Real lava does, without doubt, sometimes resemble basalt, greenstone, and other trap rocks. But it may be considered as a universal fact, that, although *calcareous spar* is often found in greenstone and basalt, it is never imbedded in those lavas, which have actually flowed on the surface of the Earth. True lava never contains metallic veins. The specular oxide of iron, sometimes found in its cavities, appears to be the result of sublimation. Lava is never stratified, although sometimes divided by fissures.

The color of compact lava, when unchanged, is most frequently brown, yellowish or reddish brown, bluish, or blackish, and sometimes gray. Its fracture is dull, and earthy or splintery. It often gives fire with steel; and almost always moves the magnetic needle. Its specific gravity is variable.—It abounds with crystals of feldspar, schorl, leucite, &c. which have been very little affected by the heat.

2. *Cellular Lava.* This lava, which is connected with the compact variety by imperceptible shades, is characterized by the pores and small cavities, which it contains, and which, according to Dolomieu, are larger near the surface, than toward the centre of the mass. These cavities may be irregular, spherical, or elongated; those of the same current being usually elongated in the same direction. They are produced by the disengagement of elastic gases, while the lava is fluid; and hence also the greater or less degree of tumefaction, which this lava always undergoes.

This lava usually moves the needle; and is sometimes sufficiently solid to give fire with steel. Its surface is rough and irregular; its color is some shade of brown, black, or gray; and its fracture earthy and dull.

It is sometimes in spherical masses, having assumed that form, when projected from the volcano into the air.

Lava, on account of its lightness, is sometimes employed in the construction of arches.—It is also used in the manufacture of green glass bottles.

Cavernous Lava. This singular lava exists in Iceland, on the great plain below Hecla. It seems to have been much tumefied, so as to produce large bubbles or blisters, of various forms, from a few feet to forty or fifty feet in diameter. Some of them are burst, and discover the *cavern*, which exists in their interior. (*MACKENZIE.*)

3. *Volcanic Scoria.* This more or less resembles the scoria of a forge in its texture, color, and form. It is more altered by the fire than cellular lava, more vitreous, more tumefied and expanded by sulphurous gas, &c. Its cavities are more numerous, larger, and more irregular, than those of cellular lava, and its surface is more uneven. It often floats on water.

Its forms are various, and sometimes much contorted. Its colors are black, brown, or gray. It has the hardness of cellular lava; but is very brittle.

Different scorice, from whatever mineral they may have proceeded, much resemble each other; and all the specimens, examined by Dolomieu, contained at least 8 per cent. of iron. It is highly probable, that the original stone abounded with sulphuret of iron; and hence the sulphurous gas, which has produced so great a tumefaction.

Volcanic scoria unites by insensible shades with cellular lava; and often contains crystals of schorl, feldspar, leucite, augite, and hornblende.

These scorice sometimes occur on the surface of currents of lava; and sometimes they are ejected from the volcano in fragments, often about the size of a nut, and fall like a shower of hail around the crater. Sometimes indeed they are ejected in such quantities, that they form little conical summits, or even small hills, on the sides of the volcanic mountain. Thus Monte Rosso, on the side of Etna, is composed in a great degree of scoria, and was formed during an eruption, which took place in 1669, and which continued three months. Its perpendicular height is about 150 paces. (*SPALLANZANI.*)—Large quantities of scoria are seen floating on the Mediterranean, in the vicinity of Stromboli, during eruptions of that mountain.

4. *Volcanic Slags.* These contain much metallic matter, are heavy, and resemble the dross of a forge.

5. *Volcanic Enamel.* This is an *imperfect* vitrification; and undoubtedly proceeds from some mineral, which is not easily vitrifiable, or which has not been exposed to a degree of heat sufficient to produce a perfect glass. It is brittle, and has the hardness of glass; but is nearly or quite *opaque*. Indeed its opacity is the principal character, in which it differs from glass. It has considerable lustre, and its colors are white,

gray, brown, &c. and sometimes spotted. Its texture and fracture sometimes approach those of glass, and sometimes resemble those of porcelain.

Some enamels contain crystals of feldspar and schorl imperfectly fused.

6. *Pumice*. This has already been described, p. 302.

7. *Volcanic Glass*. The occasional production of glass by volcanoes must arise either from an uncommon intensity in the heat, or from the more vitrifiable nature of the materials, which compose this glass.

Volcanic glass has a strong resemblance to common glass, but is sometimes so hard as to scratch it. It is more or less translucent, or even transparent in thin fragments; and has a conchoidal, shining fracture.—Its texture is sometimes perfectly compact, and sometimes more or less porous or frothy. Its colors are black, green, bluish, gray, &c.

Volcanic glass is rare, and usually occurs in small, detached pieces; it is rarely found in large continuous masses. Some volcanoes, among which is Etna, seldom or never produce perfect vitrifications.—Obsidian is by some mineralogists considered a volcanic glass.

Capillary Volcanic Glass. This is exceedingly rare. It occurs in delicate, capillary, transparent filaments, like hair, and sometimes moveable by the impulse of the breath.—It has been found in the Isle of Bourbon—at Vesuvius—at Vulcano—and in the island of Lipari. At the last mentioned place, it was observed in considerable quantities by Spallanzani.

8. *Volcanic Sand*. This sand consists of hard grains of various sizes, which appear to be chiefly fragments of scoria. These scoriæ were probably so highly tumefied by the action of elastic gases, that the aggregation of their parts was weakened or even destroyed; and, in this state, being ejected from the volcano with extreme violence, they were in some degree triturated by collision against each other.

This sand contains also fragments of lava, and crystals of schorl, feldspar, augite, &c.

Volcanic sands often cover a great extent of ground. Thus in the eruption of Etna, in 1669, when Monte Rosso was formed, a space of about fifteen miles in diameter was covered with this sand so deep, as to destroy vines and shrubs. (*SPALLANZANI*.)

9. *Volcanic Ashes*. These are extremely fine and light, dusty, and smooth to the touch. Their color is gray, sometimes a little brownish or reddish.—They sometimes contain 50 per cent. of alumine, the remainder being chiefly silex; and are hence slowly diffusible in water.

Their properties are, however, different in different volcanoes, and sometimes even in different eruptions of the same volcano.

Some mineralogists consider these ashes a very fine volcanic sand; but others suppose them to be real ashes, resulting from the combustion of coal.

The ashes of Etna, transported by the winds, have sometimes covered Malta to the depth of 2 or 3 inches ;—and, according to some ancient writers, they have reached even Egypt. They are so fine, that, like dust, they enter the closest apartments.—In 1815, a volcanic eruption in the island of Sumbowa so filled the atmosphere with fine ashes, for a considerable distance, as to render it perfectly dark for several hours. These ashes fell several inches deep on the decks of vessels, and, when mixed with water, formed a tenacious mud.

10. *Puzzolana*. This usually occurs in small fragments or friable masses, which have a dull, earthy aspect and fracture, and seem to have been baked. Its solidity does not exceed that of chalk. It is seldom tumefied ; and its pores are neither so large nor numerous, as those of scoria. Its colors are gray or whitish, reddish, or nearly black.

By exposure to heat, it loses its power of affecting the needle ; and melts into a black slag. A variety, examined by Bergman, yielded silex 55 to 60, alumine 19 to 20, iron 15 to 20, lime 5 to 6. It often contains distinct particles of pumice, quartz, and scoria.

Some mineralogists suppose the black puzzolana to be altered scoria ;—the white to be pumice, minutely divided and decomposed ;—and the red to be some mineral, which has suffered merely calcination.—Others believe, that puzzolana, in consequence of the large proportion of alumine, which it contains, has never been converted into scoria or pumice ; but has proceeded from argillaceous minerals, baked or calcined in the interior of the volcano.

But, whatever may have been its origin, it is extremely useful in the preparation of a mortar, which *hardens* quickly, even *under water*. When thus employed, it is mixed with a small proportion of lime, perhaps one third.—Mr. Kirwan supposes, that the rapid induration of this mortar arises from the very low oxidation of the iron.—If the mortar be a long time exposed to the air, previous to its use, it will not harden.

The best puzzolana is said to occur in old currents of lava ; but when too earthy, it loses its peculiar properties. That, which comes from Naples, is generally gray.

11. *Trass* or *Terras*. The nature of this is similar to that of some varieties of puzzolana ; and it contains, according to Bergman, nearly the same principles, but with a greater proportion of lime. Its hardness, however, is much greater, than that of puzzolana. Its color is brownish or yellowish ; and its fracture earthy and dull.

It often embraces fragments of argillite, hornblende, mica, a substance resembling pumice, branches of trees, &c.—It has been found chiefly near Andernach, in the vicinity of the Rhine.—It is perhaps sometimes the product of pseudovolcanoes.

Like puzzolana, this substance is useful in the preparation of mortar. It was employed by Mr. Smeaton for this purpose in the construction of the Eddystone Lighthouse.

12. *Volcanic Tufa*. This name is applied to several different substances, some of which have never suffered the action of fire, although they have proceeded from volcanoes.

1. This tufa is sometimes an aggregate of sand, volcanic ashes, and fragments of scoria and lava, united by an argillaceous or muddy cement.

2. Sometimes it is composed of volcanic ashes and sand, transported and deposited by rain water. Such tufas are constantly forming in volcanic countries.

3. The *earthy deposit*, which proceeds from muddy eruptions, has also received the name of volcanic tufa.

Tufa presents various shades of gray, brown, red, yellow, &c. or is spotted. It has a variable, but moderate, degree of hardness; and its fracture is earthy and dull. It has sometimes a uniform texture, and sometimes it embraces fragments of limestone, basalt, hornblende, schorl, feldspar, &c. &c.—The tufa of the Solfaterra, near Naples, sometimes contains impressions, or even the leaves of a species of seaweed. (*SPALLANZANI*.)

It is easy to suppose, that eruptions of *slimy earth* and *muddy water* may occasionally proceed from reservoirs in the sides or body of volcanic mountains. But it appears, that many of the volcanoes of South America often discharge vast quantities of water, and of an earthy, slimy substance, called *Moya* by the natives, and *Koth* by the Spaniards. In addition to this Moya, these volcanoes eject ashes, pumice, and slags, but seldom any lava.

Moya has a blackish brown color, an earthy texture, and but little coherence. It contains fragments of feldspar, and frequently also a great number of fishes (*Pimelodi Cyclopus*). Some varieties are combustible, and burn without flame.—A specimen yielded Klaproth silice 46.5, alumine 11.5, water, containing ammonia and empyreumatic oil, 11.0, oxide of iron 6.5, lime 6.25, coal 5.25, soda 2.5, hydrogen gas 14.5 cubic inches, carbonic acid 2.25 cubic inches.

A similar current of slimy, argillaceous earth appears to have once flowed from a volcano in the island of Lipari. (*SPALLANZANI*.)—In the island of Java, are Mud volcanoes, in which large globes or bubbles rapidly form, and burst, emitting fumes, which have the odor of sulphuretted hydrogen gas, and throwing out large quantities of salt mud at each explosion. They are in an elevated plain of mud, about 2 miles in circumference, on the plains of Grobogan, 50 miles from Solo. (*GOAD*.)—Similar volcanoes exist in Italy; Iceland; and on the southern part of the island of Trinidad.

Some naturalists suppose the water to be derived from the sea or from lakes by subterraneous passages ; and that the eruptions of volcanoes are effected chiefly by the expansion of aqueous vapor. The necessary heat may be furnished by the combustion of immense beds of coal.

Peperino. This appears to be a kind of tufa, or concretion of volcanic ashes. Its base is argillaceous, has a dull earthy fracture, a moderate hardness, and embraces grains or fragments of limestone, mica, feldspar, and scoria ; also garnets, augite, schorl, &c. Its colors are gray, reddish brown, &c. It often resembles a breccia.

In addition to the volcanic productions, already described, others are found, which have suffered calcination only—sometimes in consequence of contact with the flowing lava.

2. *Substances, ejected without alteration.*

Among these some varieties of tufa might be arranged. But volcanoes often eject fragments of granite, argillite, porphyry, greenstone, limestone, &c. and various crystals, which are sometimes scattered in the vicinity of the volcano, or enveloped in currents of lava, or of muddy eruptions. These substances are, in general, most abundant at the commencement of the eruption, and have suffered very little or no change from the action of fire. Sometimes also fragments of rocks, containing idocrase, meionite, nepheline, garnets, mica, and carbonate of lime, are ejected without alteration.—Crystals of feldspar, leucite, augite, and hornblende, though enveloped in the lava, often remain nearly, or even perfectly, unchanged by the action of volcanic fire. These crystals most probably preexisted in the rock, which yielded the lava. Hence Mr. Kirwan infers, that the heat of volcanoes, excepting when vitrifications are produced, seldom equals 120° W.

3. *Substances, sublimed by volcanic fire.*

The minerals, sublimed by volcanic fire, are condensed in the fissures or cavities of the lava and scoria, or are attached to the interior of the crater. They consist of sulphur, muriate of ammonia, sulphuret of arsenic, specular oxide of iron, &c. The first two are sometimes in sufficient quantity to be collected for use.

4. *Alterations in volcanic substances, after ejection.*

The heat of volcanic mountains, even when not in a state of great activity, is sufficient to produce a continual disengagement of sulphurous acid gas, which, by combining with more oxygen, may pass to the state of sulphuric acid. These acids attack and penetrate the lava, render it lighter and more brittle, and usually change its color to white or yellowish white ; in fine, by their combination with some of

the ingredients of the lava, several saline compounds are produced. Among these are the alkaline sulphate of alumine, and the sulphates of lime, magnesia, and iron.—Crystals of augite are sometimes rendered whitish and friable by sulphurous acid, but still preserve their form.

Even volcanic glass suffers change of color and decomposition, when attacked by the acids of sulphur. (*SPALLANZANI.*)

Lavas are also subject to a gradual decomposition by the action of the atmosphere and water, and are thus rendered friable, or converted into an earthy substance, which is remarkably favorable to vegetation, and which is often transported by water to a considerable distance.—As some lavas decompose much more rapidly than others, it is impossible to form any accurate opinion of their age by the degree of decomposition.

5. *Pseudovolcanic productions.*

The accidental or spontaneous combustion of coal mines often continues for a great length of time, and produces a greater or less change in the contiguous rocks and earths. Some of these pseudovolcanic productions have already been described under the names of porcellanite, tripoli, and polishing slate. Beds of clay are thus converted into a substance, resembling a brick in color and hardness.—In fine, tufa, scoria, and a kind of porous lava are sometimes the productions of pseudovolcanoes. On the other hand, it is obvious, that true volcanoes may sometimes produce those substances, which are usually called pseudovolcanic.

Sulphur, muriate of ammonia and other salts are sometimes sublimed by pseudovolcanoes. A remarkable pseudovolcano exists in Staffordshire, England, near Bradely iron works, and has probably been burning since 1686, at which time it is mentioned by Plott. Its ravages have extended very considerably since that time.

APPENDIX I.

METEORIC STONES.

Meteorite. Meteorolite. Aerolite. Bolide.

THOSE *stony* substances, which have fallen from the atmosphere, at different times, and in different parts of the world, have received the name of *Meteoric Stones*, or *Meteorites*, or *Aerolites*.

No subject, connected with the natural history of the earth, is more astonishing, or more difficult to explain, than the origin, &c. of these bodies, which are occasionally found on its surface. Although they have fallen in different countries, and at various periods of time, there is a strong resemblance in the phenomena, which precede and accompany their fall. But the uniformity of their external aspect, internal structure, and *composition* is still more remarkable. While, in all these respects, they strongly resemble each other, they are essentially different from any other minerals, hitherto found on the earth.

Various examples of the fall of Meteoric stones, from the time of the Roman Empire to the present day, are recorded by historians and other writers. In many of these examples the facts are perfectly well attested, while, in others, they remain doubtful.

The catalogue by *CHLADNI*, published in the *Journal de Physique*, in 1818, contains about 150 examples of the fall of Meteoric stones, exclusive of masses of meteoric iron, and also of substances, which have fallen in a soft state, either dry or moist, or in a state of powder. A long catalogue of Meteoric stones, which are said to have fallen in China, has been published in the *Journal de Physique* for 1819, by M. Abel Remusat.

We can mention but very few examples.

In 1627, the astronomer, Gassendi, saw a burning stone fall on Mount Vaiser, near Nice, in France. It weighed 59 pounds.

In 1768, near the castle of Sucé in Maine, a tempestuous cloud appeared, from which was heard an explosion, like thunder, followed by a whizzing noise in the air. An opaque body was seen to fall by several travellers, who, repairing to the spot, found a stone partly buried in the ground, and too hot to be handled.

In 1794, at Sienna, in Italy, a cloud, proceeding from the north, sent forth sparks, like a rocket; violent explosions were heard, and about 12 stones fell to the earth.

In 1795, in Yorkshire in England, noises, like the distant reports of pistols, and also a whizzing in the air were heard. A stone, weighing 56 pounds, fell to the earth, which it penetrated to the depth of 21 inches. It was warm, when first examined, and exhaled the odor of sulphur.

In 1802, near L'Aigle, in Normandy, a fiery globe was seen moving rapidly through the atmosphere; a violent explosion was heard; and a large number of stones, one of which weighed 17 pounds, fell to the earth.

In 1807, in the *United States*, at Weston in *Connecticut*, a luminous meteor appeared in the northern horizon, and proceeded nearly to the zenith with great velocity, and a waving motion. Three loud, distinct explosions were heard, and the same number of leaps or efforts in the meteor were observed. At each of these explosions or leaps, masses of stone were projected from the meteor, and fell to the earth, being scattered over an extent of about 10 miles in length and 3 or 4 miles in breadth. At the last explosion, the projected mass, which must have weighed at least 200 pounds, descended with a roaring noise and a visible curve of light.—The largest fragment of this meteor, which has been preserved, is in the rich cabinet of Col. G. Gibbs, and weighs 37 pounds.

The phenomena, which, in most cases, precede or accompany the fall of these bodies, are a luminous meteor, moving with great velocity, and sometimes throwing out sparks; an explosion, more or less violent, and, in some cases, several times repeated; and a whizzing noise in the atmosphere.

The altitude of these meteors, while they are visible, is supposed to be between 20 and 100 miles. Their velocity is estimated to be not less than 300 miles in a minute.

When examined immediately after their fall, they are hot, and often exhale the odor of sulphur. That part of the surface, which appears to have been external, is usually black and rough.

When broken, they present a basis, usually of a gray or bluish gray color, containing at least three different sorts of substances, viz. 1. dark brown or gray, spherical bodies, sufficiently hard to scratch glass, and varying in size from a grain of sand to that of a pea;—2. minute portions of pyrites, reddish yellow, friable, and often brilliant;—3. metallic iron in very minute particles, and sometimes in masses one inch or more in diameter. Their specific gravity is between 3.35 and 4.28.

These Meteoric stones exhibit a remarkable similarity in their composition. In a specimen from Yorkshire, Mr. Howard found silex 50.0, magnesia 24.7, oxide of iron 32.0, oxide of nickel 1.3;=108. Another from L'Aigle yielded Vauquelin and Fourcroy silex 54, magnesia 9, oxide of iron 36, oxide of nickel 3, sulphur 2, lime 1;=105. In another from Ensisheim, the same chemists found silex 56.0, magnesia 12.0, oxide of iron 30.0, nickel 2.4, sulphur 3.5, lime

1.4 ;=105.3. A specimen from Weston in Connecticut yielded Silliman silex 51.5, magnesia 13.0, oxide of iron 38.0, oxide of nickel 1.5, sulphur 1.0 ;=105. In a specimen from Jonzac, Laugier found silex 46.0, magnesia 1.6, oxide of iron 36.0, sulphur 1.5, oxide of manganese 2.8, chrome 1.0, lime 7.5, alumine 6.0 ;=102.4. The same chemist has also found chrome in several other Meteoric stones. In a specimen from near Langres, Vauquelin found silex 33.9, magnesia 32.0, oxide of iron 31.0, chrome 2.0 ;=98.9. A specimen from near Kostritz in Russia yielded Stromeyer silex 38.0, magnesia 29.9, protoxide of iron 4.9, nickel 1.4, sulphur 2.7, iron 17.5, oxide of manganese 1.1, oxide of chrome 0.13, alumine 3.5 ;=99.13.

The similarity of aspect and composition in almost all Meteoric stones, hitherto examined, indicates a common origin. But this origin is yet unknown. It is impossible to say where, or in what manner, Meteoric stones have been formed. We can do no more than to state the four principal conjectures on this subject; viz. 1. Meteoric stones are formed in the atmosphere. 2. They are projected from terrestrial volcanoes. 3. They proceed from lunar volcanoes. 4. They are fragments detached from terrestrial comets.

APPENDIX II.

This Appendix contains an account of those facts, which have been collected during the printing of the preceding volume. The order of arrangement is the same, as in the Tabular View. The new species are placed at the end of the Appendix.

1. SULPHATE OF BARYTES.

A specimen from Berlin in Connecticut yielded Mr. G. T. Bowen barytes 57.33, sulphuric acid 33.50, strontian 3.92, water 1.00, silex 2.50, oxide of iron and alumine 1.75. In the Sulphate of barytes from the lead mines of *Missouri* he found about one part of strontian.

2. SULPHATE OF STRONTIAN.

A specimen from an island near Put-in-Bay, in Lake Erie, yielded Mr. G. T. Bowen strontian 54.25, sulphuric acid and water 44.00, alumine 0.75, silex 0.50, oxide of iron 0.50.

3. GRANULAR LIMESTONE.

A deposit of Granular limestone or white marble has been recently discovered, by Joseph Treat, esq. in *Maine*, on the west branch of Penobscot river, about 100 miles north from Bangor, and 15 miles northwest from Ktaadn mountain. It is fine grained, white, receives a good polish, and resembles Italian statuary marble. (*TREAT.*)

4. COMPACT LIMESTONE.

A limestone, found in *New York*, in the Counties of Madison, Onondaga, and Cayuga, is employed with success to furnish lime for a water cement. It contains, according to Mr. White, lime 25.00, carbonic acid 35.05, alumine 16.05, silex 15.05, water 5.03, oxide of iron 2.02;=98.20. The price of this lime at Utica is 20 cents a bushel.

5. RHOMB SPAR.

In *Rhode Island*, at Smithfield, in good specimens, associated with silvery talc. (*WEBB.*)

6. DOLOMITE.

In *Massachusetts*, at Lee. When broken or rubbed, it is strongly fetid. (*DEWEY.*)

7. FETID LIMESTONE.

In *New Hampshire*, near Orford; it is grayish white, distinctly crystallized, is fetid by percussion and friction, and occurs in a primitive country. (*SILLIMAN.*)

8. MARL.

The variety, called *Ludus Helmontii*, is found in the *Michigan Territory*, on the eastern shore of Lake Michigan, between the rivers Black Water and Kikalemazo. (*SCHOOLCRAFT.*)

9. ARRAGONITE.

The Sarcophagus, recently found in Egypt, and mentioned p. 175, under *Alabaster*, belongs to Arragonite, according to the observations of Prof. Clarke and Dr. Wollaston.

10. PHOSPHATE OF LIME.

In a green, transparent specimen from London Grove, Chester County, *Pennsylvania*, Mr. H. Seybert found lime 55.67, phosphoric acid 44.33.

11. FLUATE OF LIME.

In *Tennessee*, Smith County, it occurs in violet or purple cubes; sometimes it is yellow, and contains brilliant pyrites. (*HARDEN.*)—In *New York*, Ontario County, at Brighton, on the east side of Genesee river. It occurs in transparent, and nearly white cubes, from $\frac{1}{2}$ an inch to $\frac{3}{4}$ of an inch in diameter, on black limestone. (*BORD* in *Silliman's Journal*, vol. iii, pp. 235, 367.)—In *Vermont*, at Putney, recently discovered by Rev. E. D. Andrews, in mica slate, which is passing into argillite. It occurs massive, and is grass or emerald green, occasionally with a tinge of purple. (*SILLIMAN.*)—Also at

Bennington, in an iron mine.—In *Massachusetts*, at Seekhonk, $\frac{3}{4}$ of a mile from India Bridge in Providence, it occurs massive in a vein of quartz, traversing sienite or granite. It is deep purple, and phosphoresces with a green light, mixed with spots of red. (*SILLIMAN*.)—In *New Hampshire*, at Westmoreland, it occurs light green. (*HALL*.)

12. SELENITE.

In *Ohio*, Trumbull County, at Ellsworth.—In *Virginia*, at the Shannondale Sulphur springs.—In *New York*, near Hudson, in clay. (*SILLIMAN*'s Journal, vol. iv, p. 51.)

13. GYPSUM.

On St. Martin's Islands, 10 miles N. E. from Michilimackinack, in large, detached masses on the soil; it is granularly foliated, and mixed with scattered masses of the fibrous variety;—also on Grand River, which empties at the eastern side of Lake Michigan. (*SCHOOLCRAFT*.)

14. CARBONATE OF MAGNESIA.

In *New Jersey*, at Hoboken, forming veins in serpentine. It is white, has a compact texture, and usually presents a splintery fracture. A specimen, analyzed by Nuttall, yielded magnesia 44.00, carbonic acid and water 50.00, lime 3.50, silex 2.00, protoxide of iron 0.50. The proportion of lime is extremely variable.

A specimen of native Carbonate of magnesia from India yielded Henry magnesia 46.00, carbonic acid 51.00, water 0.50, insoluble matter 1.50;=99. The specimen was snow white, and slightly translucent at the edges; its fracture was conchoidal passing into uneven, and dull; and its specific gravity 2.56. Though not easily scraped by a knife, it did not scratch fluat of lime.—In cold acids it dissolved very slowly, even when in powder. (*HENRY*.)

15. QUARTZ.

In *Massachusetts*, at Brighton, in cavities in amygdaloid; the crystals, sometimes four inches long, are well formed, opaque, and colored green by green earth. (*WEBSTER*.)

16. CARNELIAN.

In the *United States*; near Sandy Lake, at the head of the Mississippi—and near Lake Pepin, on the same river; it is often associated with common chalcedony, cacholong, &c. (*SCHOOLCRAFT*.)

17. CYANITE.

In *New York*, near the city, in granite; recently discovered by Mr. Cozzens. (*TORREY*.)

18. STAUROTIDE.

In *Vermont*, at Putney, in mica slate. (*HALL*.)—In *Massachusetts*, at Pittsfield, it occurs in small, light brown crystals, either single, or crossing each other at oblique angles; it is associated with garnets and sulphuret of iron. (*HALL*.)

19. CHRYSOBERYL.

In *New York*, in Saratoga, about one mile north from the high-rock springs, in a vein of granite, traversing gneiss. It is greenish yellow, and translucent. The forms of its crystals are incomplete, but usually present two or more perfect sides, some of which frequently exhibit parallel or diverging striæ. (*STEEL*.)—Also in *Connecticut*, at Haddam, on the *east* side of the river. (*SILLIMAN*.)

20. MICA.

In *New York*, in Saratoga, about one mile north from the high-rock springs, prismatic Mica occurs in a vein of granite, traversing gneiss. It is transparent, and composed of delicate filaments, resembling those of amianthus. (*STEEL*.)—Also in *Massachusetts*, at Hinsdale, it occurs green. (*J. PORTER*.)

21. TOURMALINE.

Mr. H. Seybert has detected the boracic acid in the green, blue, and red Tourmalines of *Massachusetts*;—and also in black schorl from near Haddam in *Connecticut*, and from near Chester, Delaware County, in *Pennsylvania*.—In *Maine*, at Paris, are found large, well defined crystals of black schorl. (*HAMLIN*.)

22. EMERALD.

In *Maine*, at Paris, in granite. (*HAMLIN*.)

23. GARNET.

In an amorphous, brownish yellow garnet, accompanying the Franklinite from Sparta, in *New Jersey*, Mr. H. Seybert found silex 32.80, lime 27.80, alumine 3.06, magnesia 1.24, protoxide of iron 27.56, of manganese 6.32, water 1.10;=99.88.

24. COLOPHONITE.

In a specimen from Willsborough, *New York*, Mr. H. Seybert found silex 38.00, lime 29.00, alumine 6.00, protoxide of iron 25.20, water 0.33;=98.53.

25. MANGANESIAN GARNET.

A specimen from Haddam, in *Connecticut*, yielded Mr. H. Seybert silex 35.83, alumine 18.06, protoxide of manganese 30.96, protoxide of iron 14.93, water 0.66;=100.44.

26. EPIDOTE.

In *New York*, on the west shore of Lake George, 8 miles from Ticonderoga, it occurs compact, and deep yellow with a shade of green. (*SILLIMAN*.)—In *Rhode Island*, at Cumberland, on Tower Hill, both massive and crystallized, in quartz. (*WEBB*.)

27. ZOISITE.

In *Massachusetts*, at Leyden, it has a dirty gray color, and sometimes forms the gangue of the red oxide of titanium. (*HALL*.)—In *Vermont*, at Wardsborough, in quartz. It occurs in gray or greenish gray, prismatic crystals, generally much compressed, often aggregated, and sometimes one foot or more in length, and one or two inches wide. (*DEWEY*.)—Also at Brattleborough.—In *New Hampshire*, at Westmoreland, in light gray, much compressed, and deeply striated crystals, translucent near the acute angles. (*HALL*.)

28. SCHAALSTEIN.

In a specimen from Willsborough, *New York*, Mr. H. Seybert found silex 51.00, lime 46.00, alumine and oxide of iron 1.33, water 1.00; = 99.33, with a trace of magnesia.

29. APOPHYLLITE.

In New South Shetland. It occurs in low, rectangular prisms, with truncated solid angles. Some of the crystals are $\frac{3}{10}$ of an inch long. It is associated with calcareous spar. (*TRAILL*.)

30. HYPERSTHENE.

The Hypersthene from Dupont's farm, near Wilmington, *Delaware*, strongly resembles the Hypersthene from Labrador; but it is magnetic, and fusible by the blowpipe. It contains silex 52.17, lime 20.00, magnesia 11.33, alumine 4.00, deutoxide of iron 10.73, water 1.00; = 99.23. (*H. SEYBERT*.)

31. TREMOLITE.

In *Rhode Island*, at Smithfield, it is found white and fibrous, in limestone;—at Cumberland, on Tower Hill, it is green of different shades, and associated with actynolite. (*WEBB*.)

32. ASBESTUS.

In *Vermont*, at Barton, is found Amianthus in very delicate, white fibres;—and at Windham and Mount Holly, the ligniform variety occurs. (*HALL*.)

33. AUGITE.

In a crystallized specimen from near Ticonderoga, *New York*, Mr. H. Seybert found silex 52.66, lime 23.33, magnesia 5.73, alumine 6.66, protoxide of iron 12.30, water 0.33; = 101.01, with a trace of manganese.

34. COCCOLITE.

A specimen from near Ticonderoga, *New York*, yielded Mr. H. Seybert silex 51.00, lime 23.00, magnesia 6.26, alumine 3.00, protoxide of iron 14.43, water 0.66; =98.35, with a trace of manganese.

35. ACTYNOLITE.

A specimen of the glassy variety from Concord, Delaware County, *Pennsylvania*, yielded Mr. H. Seybert silex 56.33, magnesia 24.00, lime 10.66, alumine 1.66, water 1.03, protoxide of iron 4.30, with a trace of chrome; =97.98.—Actynolite is found in *Connecticut*, at Saybrook.—In *Massachusetts*, at Middlefield and Cummington.

36. HYDRATE OF MAGNESIA.

This mineral, discovered by Dr. Bruce of New York, has since been found at Swinanes, in Unst, one of the Shetland Isles. It forms veins from half an inch to six or eight inches wide, traversing serpentine, and is mixed with magnesian carbonate of lime. It contains, according to Dr. Fyfe, magnesia 69.75, water 30.25.

Nemalite or *Amianthoid Magnesite*. This name is given by Mr. T. Nuttall to a mineral, found in the serpentine rocks of Hoboken, in *New Jersey*. It has a fibrous structure, a silken lustre, and strongly resembles amianthus. Its fibres are flexible, but do not, like those of amianthus, when presented to the flame of a candle, melt into a globule at their extremities. Its color is usually pale blue; and its specific gravity is 2.44.

Before the blowpipe it is infusible; but becomes friable, opaque, and light brown. By exposure to a strong heat it loses about 30 per cent. It is almost totally soluble in acids, without effervescence; and by sulphuric acid is converted almost entirely into sulphate of magnesia.

37. SERPENTINE.

In *Vermont*, at Ludlow and Cavendish, on the north side of the turnpike from Rutland to Boston; it is deep green with streaks of yellow and white. (HALL.)

38. TALC.

In *Rhode Island*, at North Providence, it occurs green;—and at Smithfield, it is silvery, and associated with rhomb spar. (WEBB.)—In *Vermont*, at Grafton, it is laminated, and forms veins from one inch to six inches wide, traversing steatite. (HALL.)

39. STEATITE.

In *Massachusetts*, at Middlefield, it occurs in crystals, usually grouped, on masses of Steatite. Some of the crystals are $\frac{3}{8}$ of an inch

in diameter, and more than half an inch long. Their color is yellowish white; but the surface by exposure becomes brown. Their fracture is uneven; and they present, especially near the surface, a structure somewhat fibrous. Their predominant form is a six-sided prism, terminated at one or both of its extremities by a six-sided pyramid. The prism and pyramids are liable to truncation on their edges and solid angles. Prof. Dewey is inclined to consider them true crystals. (*DEWEY.*)

40. CHLORITE.

In *Pennsylvania*, near the Falls of the Schuylkill, discovered by Mr. T. Nuttall. It is deep bottle green, and occurs foliated, mammillary, and botryoidal, in a hornblende rock.—In *Massachusetts*, near Lanesborough, it is abundant, and often associated with detached masses of quartz. (*SILLIMAN.*)—In *Vermont*, at Wardsborough, in quartz. It occurs in distinct, dark green folia, which often form cylindrical masses. (*DEWEY.*)

41. GREEN EARTH.

In a specimen from Ancocus Creek, *New Jersey*, Mr. H. Seybert found silex 49.83, alumine 6.00, magnesia 1.83, potash 10.12, water 9.80, protoxide of iron 21.53;=99.11, with a trace of oxide of chrome.

42. ANTHRACITE.

In *Pennsylvania*, near Wilkesbarre, &c. mentioned p. 501. The quantity of Anthracite, annually sent into market from the Lehigh and Schuylkill mines, is from 1000 to 1500 tons. (*CIST.*)

43. GRAPHITE.

In *North Carolina*, a few miles north from Raleigh, of good quality, and abundant. (*SILLIMAN'S* Journal, vol. iv, p. 53.)—In *Maine*, at Greenwood, 6 miles from Paris Court House. (*HAMLIN.*)

44. NATIVE GOLD.

The value of the Native Gold from North Carolina, received at the mint of the United States from 1810 to 1820, is about \$19,000. (*SEYBERT.*)

45. ARSENICAL IRON.

In *Connecticut*, at Chatham, in the cobalt mine. (*TORREY.*)—In *Maine*, at Paris, in granite. (*HAMLIN.*)

46. SULPHURET OF IRON.

In *Kentucky*, at Scotville, in cubic and octaedral crystals, so extremely minute, that they resemble brass filings. (*GILMOR.*)

47. MICACEOUS IRON.

In *Massachusetts*, near Northampton. It has a high lustre, and is contorted. (*SILLIMAN*.)—In *Vermont*, at Jamaica. Its masses are composed of extremely minute plates, which feebly cohere. (*SILLIMAN*.)

48. RED HEMATITE.

In *New York*, at Anthony's nose, a few miles south from Ticonderoga, it occurs mammillary, botryoidal, &c. Its color and that of its powder are bright red. (*SILLIMAN*.)—In *Rhode Island*, at Cumberland, on Diamond Hill, it is botryoidal, mammillary, &c. (*WEBB*.)

49. YELLOW OCHRE.

In *Vermont*, at Brandon, associated with the brown and compact red oxides of iron. This deposit of Ochre is found a few feet under the surface of a horizontal plain. The ore is abundant, and yields, on an average, 30 per cent. of excellent iron;—also at Bennington. (*HALL*.)—In *Maine*, at Paris, Buckfield, and Rumford; it has a good color, and is employed as a pigment. (*HAMLIN*.)

50. LENTICULAR OXIDE OF IRON.

In *Massachusetts*, at Sharon, in a pond. (*WEBB*.)

51. SULPHATE OF IRON.

In *Maine*, at Hebron, forming an efflorescence. (*HAMLIN*.)

52. CHROMATE OF IRON.

An amorphous specimen, from the Bare Hills near Baltimore, yielded Mr. H. Seybert peroxide of iron 36.00, protoxide of chrome 39.51, alumine 13.00, silex 10.60;=99.11. In another, from Delaware County, *Pennsylvania*, the same chemist found peroxide of iron 35.14, protoxide of chrome 51.56, alumine 9.72, silex 2.90;=99.32.

53. CARBONATE OF LEAD.

In a specimen of the earthy variety from Austin's mine, Wythe County, *Virginia*, Mr. H. Seybert found protoxide of lead 69.44, carbonic acid 12.80, clay 6.60, peroxide of iron 6.00, water 3.60;=98.44.

54. SULPHATE OF LEAD.

In *Connecticut*, at Huntington, in Lane's mine, it incrusts argenteriferous galena. It is said to contain silver. (*SILLIMAN*.)

55. OXIDE OF COBALT.

In *Maryland*, near Baltimore, Oxide of cobalt, connected with oxide of manganese, is found in an alluvial deposit of sand. It occurs in bluish black masses, which appear to be composed of grains of sand, cemented by the two aforementioned oxides. (*HARDEN*.)

56. OXIDE OF MANGANESE.

In *Pennsylvania*, it occurs on the head waters of Bear creek, Lehigh, and Tobyhannah, on Broad Mountain. It is sometimes in compact, indurated, detached masses, varying in size from that of a walnut to that of a man's head—sometimes its texture is porous or spongy—and sometimes it is cellular, the cavities being lined with minute, brilliant globules. (*CIST.*)—In *Massachusetts*, at Sheffield.

57. SULPHURET OF MOLYBDENA.

In a specimen from near Chester, Delaware County, *Pennsylvania*, Mr. H. Seybert found molybdena 59.42, sulphur 39.68 ;=99.10.—In *Maine*, it is found at Paris and Buckfield with sulphuret of iron. (*HAMLIN.*)

58. RED OXIDE OF TITANIUM.

In *Connecticut*, at Huntington, near Lane's mine. The crystals, sometimes as large as the thumb, are often geniculated. When in irregular masses, it resembles garnet. (*SILLIMAN.*)

59. SILICO-CALCAREOUS OXIDE OF TITANIUM.

In *Vermont*, at Dummerston, in crystals or grains, disseminated in granite. Its color is dark or chestnut brown; and its specific gravity is between 3.31 and 3.37. (*DEWER.*)

60. FERRUGINOUS OXIDE OF COLUMBIUM.

This mineral is said to have been recently observed by Berzelius in a specimen of granite from Haddam, in *Connecticut*. It occurs in small prisms in the same granite, which contains the chrysoberyl. (See *SILLIMAN'S Journal*, vol. iv, p. 52.)

61. EUDIALYTE. JAMESON.

It is brownish red; has an octahedral cleavage; and is a little harder than the apatite. Its specific gravity is between 2.8 and 3.0.

62. GIBBSITE. TORREY.

This mineral has already been mentioned p. 224, in an appendix to phosphate of alumine.

It occurs in irregular, stalactical masses from one inch to three inches in length, and one inch or more in breadth. These masses present an aggregation of elongated, tuberous branches, parallel and united. Sometimes it appears in larger, tuberous masses. Its structure is indistinctly fibrous, and the fibres radiate from an axis.—It is a little harder than calcareous spar; but is easily reduced to powder.—It is slightly translucent; and has but little lustre. Its colors are dirty white, greenish white, and grayish.—Its specific gravity is 2.40.

(*Chemical characters.*) Before the blowpipe it whitens; but is infusible. It does not effervesce in acids. It is composed, according to Torrey, of alumine 64.8, water 34.7;=99.5.

It is found in *Massachusetts*, at Richmond, in a neglected mine of brown hematite, where it was discovered by Dr. E. Emmons. Its geological associations are unknown.

This mineral was examined about the same time by Dr. J. Torrey of New York, and by Prof. Dewey. Their analyses give similar results.

We are indebted for the foregoing description to Dr. Torrey, who has proposed for this mineral the name of *Gibbsite*; in honor of Col. George Gibbs, who has so eminently contributed to the advancement of American mineralogy.

63. GIESECKITE. JAMESON.

Its form is rhomboidal; and its texture compact. It is gray or brown; and has nearly the hardness of calcareous spar. Its specific gravity is between 2.7 and 2.9.

64. MACLUREITE. SEYBERT.

The mineral, for which Mr. H. Seybert proposes the above mentioned name, is composed, according to his experiments, of silex, magnesia, and fluoric acid. It is found in *New Jersey*, Sussex County, near Sparta, in carbonate of lime.

It appears to be the same mineral, already mentioned, p. 295, under the name *Brucite*.

REMARKS

on the Geology of the United States, explanatory of the subjoined geological map. (Pl. VI.)

THE object of this article is to give a brief and general view of the present state of our knowledge in regard to the Geology of the United States, and to explain the subjoined map. For most of the observations, here given, the writer is indebted to the second edition of a printed memoir by W. Maclure, and to written communications from H. H. Hayden of Baltimore. The geological boundaries on the map, taken chiefly from the aforesaid memoir by Mr. Maclure, and from his geological map of the United States, published in the Transactions of the American Philosophical Society, vol. i, new series, are applied to the geographical map, recently published by Cummings and Hilliard.—The principal variation from Mr. Maclure's map appears in the extension of the alluvial deposite in New Jersey, as suggested by James Pierce, esq.

There are several reasons, which render it important, that the geological relations of the various and extensive formations of minerals, which occur in the United States, should receive peculiar attention. One important reason is the facility, with which geological observations may be here made, in consequence of the great extent, uniform structure, and regular stratification, which so often appear in rocks, belonging to the same formation. For it is obvious, that, under such circumstances, general principles can be more easily and satisfactorily established, than in those countries where the strata are often broken and discontinued, and where the action of earthquakes, volcanoes, torrents, &c. has produced irregularity and confusion in the arrangement of the strata.

The United States present extensive masses and strata, not only of *primitive, transition, and secondary* rocks, but also of *alluvial* deposites. —On the *eastern* side of Hudson's river, there is very little of alluvial deposite; and the rocks, with a few exceptions, belong to primitive formations. But, between the Hudson and the Mississippi, are found alluvial deposites, primitive, transition, and secondary rocks, so arranged, that the direction of their length is from northeast to southwest and nearly parallel to the line of the sea coast. Hence a traveller, in the middle or southern States, passing northwest from the Atlantic

toward the Lakes, would meet successively the preceding four great classes of mineral substances in the order just mentioned.

The geological boundaries and characters of these several classes require more particular description.

*Alluvial Deposit.**

Painted on the map gamboge yellow.

The northern extremity of this deposit is at Long Island, all of which appears to be alluvial, excepting the margin of the shore at Hurlgate, where primitive strata appear for the distance of four or five miles. On the east and southeast, this alluvion is bounded by the Atlantic; and on the south, by the Gulph of Mexico to the Mississippi. Its northwestern or interior boundary, commencing a little below Newark, runs north of Amboy to the Raritan, and thence passes near Trenton, Philadelphia, Baltimore, Washington, Fredericksburg, Richmond, Petersburg, a little west of Halifax, Smithfield, and Averysborough in North Carolina, and of Camden in South Carolina, near Columbia, Augusta on the Savannah, and thence, bending to the west, it crosses the Ogeechee, Oakmulgee, Alabama, and Tombigbee rivers, and reaches the Mississippi a little below Natchez.

The elevation of this deposit above the level of the sea gradually diminishes in passing from Georgia to New York. From the Mississippi to the Roanoke, the tide does not reach the northwestern boundary of this alluvion; but, from the Roanoke to the Delaware, it enters the primitive range.

This very interesting Deposit has been examined in but few points, and in no one, perhaps, to a sufficient depth. Through its whole extent, there is very little, which deserves the name of a rock. In Maryland, about 15 miles south from the *granitic ridge*, or border of the primitive, is a bed of sandstone, whose direction is parallel to that of the ridge. In North Carolina also a bed of limestone and shells commences about 20 or 30 miles from the border of the primitive, to which it runs parallel through South Carolina, Georgia, &c. In some points, as in Georgia, a variety of buhrstone is found.

The great mass of this alluvial deposit, below the soil, is composed of sand, gravel, pebbles, and clay, the last of which, either white or variously colored, sometimes forms extensive beds. These beds of sand, either brown and ferruginous, or white and pure, often present an undulated or wavy appearance; and sometimes, especially in their higher parts, embrace extensive beds of pebbles of quartz, &c. Sometimes also the gravel or sand is converted into a kind of ferruginous pudding or sandstone.

* See Geological Essays, &c. by Horace H. Hayden, esq. of Baltimore.

This Deposit contains numerous and valuable beds of the argillaceous oxides of iron; and sometimes also of the sulphuret of iron. Beds of shells, teeth and bones of sharks, whales, birds, &c. and remains of vegetables are found in various parts of this Alluvial Deposit, sometimes at the depth of nearly 100 feet, and sometimes enveloped in a kind of mud, which appears to be the alluvion of an ancient sea. Beds of marl, which seem to have derived their calcareous ingredient from shells, are sometimes observed.

When this Alluvial Deposit is composed of fine sand, and destitute of any incumbent soil, very important changes are often produced by the action of wind. Thus at Cape Henry, in Virginia, hills are formed, and trees buried beneath the sand, which is gradually transported by the winds.

Primitive Rocks.

Painted on the map vermillion red.

The primitive formations extend from northeast to southwest through nearly the whole territory of the United States. *Eastward* of the Hudson, the rocks are, with a few exceptions, entirely primitive, and have the Atlantic for their eastern boundary. The apparent breadth of this primitive tract is much diminished in the middle states; but in the southern states is again enlarged.—From the Hudson to the Tombigbee, its visible boundary, on the southeast, is, with a very few exceptions, the aforementioned alluvial deposit; under which, however, it undoubtedly extends more or less. Its northwestern boundary (see map), after crossing the parallel of 45° N. latitude, runs 15 to 20 miles east of Lake Champlain, 12 miles east of Middlebury, and a little westward of Bennington in Vermont, 12 to 15 miles east of Hudson, and 12 miles southeast of Poughkeepsie in New York; it then bends to the southwest, crosses the Hudson, passes near Sparta, and 10 or 15 miles east of Easton on the Delaware, terminating in a point a few miles north of Bethlehem; it again appears 15 miles west from Trenton in New Jersey, runs about 15 miles west of Philadelphia, 10 miles east of York, and, passing about 22 miles west of Washington, joins the Blue Ridge, along which it continues to Magothy Gap; and thence passes in a southwesterly direction, till it meets the alluvial deposit near the river Alabama.

Primitive rocks also appear westward of Lake Champlain, and have, for their general boundaries, Lakes Champlain and George on the east, the St. Lawrence on the northwest, and a line drawn from the Thousand Islands in the St. Lawrence, passing near the Mohawk, and terminating at Lake George, on the southwest. (See map.)

The strata of this primitive region vary in direction from north and south to northeast and southwest; they almost invariably dip or

incline to the southeast at a greater angle than 45° , and are sometimes almost vertical.

Within the limits, already assigned to the primitive strata, are found several transition and secondary formations, of comparatively small extent, resting upon the primitive;—as is obvious from an inspection of the colored map.—Thus, transition rocks (*rose red*) extend from Rhode Island to Boston. They again appear on the southwest side of the Delaware, and extend to the upper branches of the Yadkin in North Carolina, forming a narrow deposit of uncommon length, and varying in breadth from two to fifteen miles.—Secondary rocks (*pale blue*) extend from New Haven to Northfield in Massachusetts, lying principally on the western side of Connecticut river. They appear again southwest of the Hudson; at the Delaware their breadth is much diminished; they pass a few miles west of York in Pennsylvania, and, crossing the transition rocks already mentioned near the Potowmac, they terminate a little southwest of the Rappahannock.—A coal formation, composed of secondary rocks, is also found a little west of Richmond, in Virginia.

One of the most remarkable circumstances, connected with these primitive rocks, is the *granitic ridge*, which forms the boundary between the primitive and alluvial regions. This granitic ridge appears to have been the ancient line of the sea coast in the southern and middle states, and very probably through Connecticut. It commences at least as far south as Georgia; and its general direction is from southwest to northeast, sometimes varying to almost north and south or east and west. The Roanoke crosses it near Halifax; James River at Richmond; the Rappahannock at Fredericksburg; the Potowmac at Georgetown; and the Petapsco between ten and fifteen miles from its influx into Chesapeake Bay. It sometimes disappears under the soil; but at the point where it crosses the Susquehanna, it rises to a greater height and is more rugged, than usual. At Trenton it meets the Delaware. After crossing York Island, it again appears near Hurlgate on Long Island. From Hurlgate, this granitic ridge, in the opinion of Mr. Hayden, extends along the north shore of Long Island, dips under the passage between that island and Fisher's Island, which it crosses; and again dipping under the passage between Fisher's Island and the Continent, appears once more at Watch Hill Reef, not far below Stonington in Connecticut.

It is obvious, that this opinion of Mr. Hayden is by no means at variance with the facts, stated by Dr. Mitchill, according to which, nearly the whole of Long Island is colored on the map, as alluvial. For this *ridge*, while traversing a part of the northern boundary of Long Island, may so dip as to be covered by 70 or 80 feet of alluvial earths.—On

the other hand, if this opinion is correct, it is exceedingly probable, that this granitic ridge once formed the southern boundary of what is now the states of New York and Connecticut.

It has already been remarked, that many formations of rocks in the United States are distinguished by their great extent and remarkable uniformity. An example of this exists in the vicinity of the granitic ridge just described. For, if a particular mineral occur two or more miles north of this ridge in Virginia or Maryland, it may generally be found at about the same distance north of the ridge in Pennsylvania, &c. This is the case with certain magnesian minerals, chromate of iron, &c.

Transition Rocks.

Painted on the map rose red.

The greater part of the transition rocks, found in the United States, lie northwest of the primitive, and form a long and narrow zone, extending from a little northeast of the Hudson nearly to the river Alabama. The breadth of the zone is from 20 to 100 miles. The strata generally dip to the northwest; and their inclination is, in most places, less than 45° .

The Transition rocks, on their northwest border, are often intermingled with secondary rocks, the latter appearing in vallies, and the former in the surrounding mountains.

Among these rocks are found limestone of various colors, graywacke, graywacke slate, siliceous slate, amygdaloid, breccias, both siliceous and calcareous, and several other aggregates, not hitherto named or described.

Secondary Rocks.

Painted on the map pale blue.

This great Secondary deposit lies northwest of the transition rocks, extending from them to the Lakes, and from the Hudson to the westward of the Mississippi. This deposit is, in fact, equally remarkable both for the extent and uniformity of the formations, which it embraces, and which consist of limestone and sandstone in strata nearly horizontal, on which often rests the Independent coal formation.

According to Mr. Maclure, there is reason to believe, that this secondary deposit extends westward of the Mississippi nearly to the foot of the Stony Mountains, thus presenting an area, whose diameter from east to west is about 1500 miles, and from north to south about 1200 miles.—In fine, it is suggested by this celebrated geologist, that all this extent of secondary rocks was once the bottom of a great Lake or Sea;—and that the waters of this Lake have been gradually discharged by the Mississippi, the Hudson, and the St. Lawrence, the only rivers, that have completely broken through the mountains, which once surrounded this immense basin of water.*

* Want of color indicates that the common boundary is not ascertained, the two classes of rocks being somewhat intermingled; or that such portions of the United States have not been examined.

VOCABULARY,

*containing an explanation of certain terms, used in the preceding volume ; more particularly those, which relate to the Chemical Nomenclature.**

ACICULAR. Long and slender, like a needle. (See p. 31.)

ACIDS. Most of the acids are known to be compounds of oxygen, in certain proportions, with a combustible base. Thus *sulphur*, united with a given quantity of oxygen, forms *sulphuric acid*. The name of the acid is derived from that of the *base*, or from that of the substance, which furnishes the acid, and always terminates with the syllable *ic*, as in the preceding example, unless the same base be capable of furnishing *two* acids. When this is the case, the two acids differ from each other by containing different proportions of oxygen ; and the name of that acid, which contains the smaller proportion of oxygen, terminates with the syllable *ous*, as *sulphurous acid*. Hence the *sulphurous acid*, by the addition of oxygen, passes to the *sulphuric*.—Some acids exist in the state of a gas ; some are liquid ; and others are solid. They change a vegetable blue color to red ; and most of them have a taste more or less distinctly *sour*.—They combine with alkalis, earths, and metallic oxides ; and thus form alkaline, earthy, and metallic *Salts*. The number of acids is about 50.

AGGREGATE. A rock, composed of two or more simple minerals ; as granite, consisting of feldspar, quartz, and mica.

ALKALIS. Certain substances, which, when pure, have an acrid or a burning taste, and are caustic, when applied to the flesh. They are very soluble in water and rapidly combine with acids, thus forming *alkaline salts*, of which sulphate of soda is an example. They change a vegetable blue to green.—There are three alkalis, viz. potash, soda, and ammonia, which have been long known ; the first two are solid and *fixed*, and the last is gaseous and *volatile*.—Another alkali, recently discovered in minerals, is called lithia.

ALLOY. A combination of any two or more metals in a metallic state.

AMALGAM. A combination of any two metals, of which mercury is one.

AMORPHOUS. Not having a regular or determinate form. (See p. 52.)

* For an explanation of terms, employed in describing the imitative forms and other external characters of minerals, see Introduction, chap. 2, sect. 2.

ARSENIATE. A salt, formed by the union of *arsenic* acid with any base. Thus, Arseniate of copper is composed of arsenic acid and oxide of copper.

ARSENIC ACID. A compound of about 64 parts of arsenic and 36 parts of oxygen.

BASE. A chemical term, applied to one of the ingredients of a compound. Thus in carbonate of lime, the lime is said to be the *base* of this earthy salt.

BEVELMENT. (See p. 29.)

BLADED. When a mineral is composed of long and narrow plates or laminæ, like the *blade* of a knife, it is said to have a bladed structure. (See p. 61.)

BORACIC ACID. A compound of oxygen with a base, which is supposed to be metallic, and has received the name *Boracium*, or *Boron*.

BORATE. A salt, formed by the union of *boracic* acid with a base; as Borate of magnesia, composed of boracic acid and magnesia.

BOTRYOIDAL. Resembling a bunch of grapes. (See p. 51.)

BOULDER. A term applied to loose masses or fragments of rocks, as of granite, greenstone, &c.; they are found on the surface of the soil, are sometimes very large, and usually exhibit marks of having been rolled or rounded.

CALCAREOUS. This epithet is applied to those minerals or mountains, which are composed chiefly or entirely of carbonate of lime.

CALCINATION. The exposure of metallic and other substances to that degree of heat, which drives off their volatile parts, and produces some other changes, but does not effect fusion.

CAPILLARY. Resembling a hair. (See p. 50.)

CARBON. A simple, combustible substance. Charcoal, recently and carefully made, is *carbon* nearly or quite pure. Carbon also exists native in the diamond.

CARBONATE. A salt, formed by the combination of *carbonic* acid with any base. Thus, Carbonate of lime is composed of carbonic acid and lime.

CARBONIC ACID. A compound of about 29 parts of *carbon* and 72 parts of oxygen.

CARBURET. This name is given to certain compounds, of which *carbon* forms one ingredient; as Carburet of iron, composed of carbon and iron.

CARBURETTED HYDROGEN GAS. A variety of hydrogen gas, holding *carbon* in solution. (See p. 481.)

CHATOYANT. When different collections of colors alternately appear and disappear, according to the position of the mineral. (See p. 46.)

CHROMATE. A salt, composed of *chromic acid* united with some base. Thus, Chromate of lead is a compound of chromic acid and oxide of lead.

CHROMIC ACID. A compound of about 60 parts of *chrome* and 40 parts of oxygen.

CLEAVAGE. (See p. 9.)

COAL MEASURES. A coal formation, including the several minerals, which accompany the coal.

COMBUSTION. In most cases of Combustion, *oxygen* combines with the combustible, or with some of its ingredients; and the products of Combustion are an *oxide, acid, or alkali*. The oxygen is usually furnished by the air.

CONCENTRIC. When a mineral is composed of several curved layers, lying over each other, and having the *same centre*, the layers are said to be *Concentric*. The external form of such minerals is generally spherical, mammillary, &c.

CONCHOIDAL. The surface of a Conchoidal fracture presents small elevations and depressions, as if it had been impressed by the shell of a fish. (See p. 62.)

CONCRETION. A term often applied to the small, distinct portions or masses, of various forms, of which some minerals are composed. (See p. 55.)

CORRODED. Containing numerous cavities, as if worm eaten.

CUNEIFORM. Having the form of a wedge. (See p. 30.)

DEBRIS. A term sometimes applied to the fragments or remains of disintegrated rocks.

DECREPITATION. When a salt or other mineral, thrown into a red hot crucible, or exposed to the action of the blowpipe, yields a crackling noise and splits, or is even dispersed in small fragments, it is said to *decrepitate*.

DENDRITIC. Branching, like a tree or shrub. (See p. 50.)

DENTIFORM. Like a tooth.

DIEDRAL. Having two sides. A crystal, terminated by two faces, inclined to each other, and meeting in an edge, is said to have a *diedral* summit.

DIKE. A term sometimes applied to veins of basalt, greenstone, and other stony substances.

DISINTEGRATION. When a mineral, by the action of air and moisture, is rendered friable, or actually crumbles, it is said to be *disintegrated*. Hence it is a different change from that, which is called decomposition.

DODECAEDRON. A solid bounded by twelve faces.

DRUSES. Cavities, whose interior surface is lined with crystals; they occur most frequently in veins. (See p. 33.)

DRUSY. An epithet applied to a surface, covered with minute crystals.

EARTHS. The number of Earths is ten, viz. barytes, strontian, lime, magnesia, alumine, silex, glucine, zirconia, yttria, and thorina.

EARTHY. A variety of fracture. (See p. 62.)

EARTHY SALTS. Those salts, which have an *earth* for their base; of which sulphate of *lime* is an example.

EFFERVESCENCE. An intestine motion, like boiling, in a fluid, being produced by the escape of some gas in the form of little bubbles. Effervescence may appear during the solution of certain minerals in acids, or during their fusion by the blowpipe.

EFFLORESCENCE. A salt is said to *effloresce*, when, by exposure to the air, it loses its water of crystallization, and falls into a powder.— It is also said to occur as an *efflorescence*, when it exists native in the form of a crust or powder on the surface of other minerals.

FASCICULAR. An epithet applied to a group of minute crystals or fibres somewhat diverging, like a bundle of rods. (See pp. 32, 59.)

FILIFORM. Like a thread.

FLUATE. A salt, formed by the union of *fluoric* acid with any base. Thus, Fluate of lime is composed of fluoric acid and lime.

FLUORIC ACID. It has not been satisfactorily analyzed; but its base is probably metallic.

FOLIATED. (See p. 60.)

FRIABLE. A mineral is friable, when the grains or small parts, of which it is composed, so slightly cohere, that they may be separated by a gentle pressure. (See p. 56.)

GALLATE. A salt, composed of *gallic* acid and a base.

GANGUE. The mineral, in which an ore is embraced, or with which it is mixed. Thus, when sulphuret of lead is imbedded in limestone, the latter is called its *gangue*, or *matrix*. (See p. 521.)

GAS. A substance, which exists permanently, or at least usually, in the state of an elastic, aeriform fluid. Solids and liquids are converted into gases by the action of caloric.

GEODE. A ball more or less hollow. Its interior is sometimes lined with crystals. (See p. 51.)

HEPAR. HEPATIC. (See pp. 482, 589.)

HEMITROPE. When a crystal is composed of two equal parts, one of which appears to have turned through half the circumference of a circle. (See p. 32.)

HYDRATE. A compound, of which *water* in a solid state forms an essential ingredient. Thus, Hydrate of iron is a compound of water and oxide of iron.

HYDROGEN. A simple, combustible substance. It forms an ingredient of water, which is composed of about 12 parts Hydrogen and 88 parts oxygen, by weight.

HYDROGEN GAS. Solid hydrogen, rendered gaseous by combining with caloric. It is very light, and highly inflammable.

HYDROPHANOUS. (See p. 48.)

IN PLACE. IN SITU. These expressions are applied to minerals, when found in permanent and more or less extensive beds, strata, &c. to distinguish them from loose, insulated, or detached masses.

IRISED. IRIDESCENT. When the colors of a mineral resemble those of the *iris* or rainbow; they are not changeable. (See p. 46.)

LAMELLÆ. Small, thin plates or layers.

LAMELLAR. (See p. 60.)

LAMINÆ. Thin leaves, plates, or layers.

LAMINATED. (See p. 60.)

LENTICULAR. Resembling a convex lens. (See p. 31.)

LIXIVIATION. The dissolving of an alkali or a salt in water, thus forming a lixivium or lie.

LODE. A term sometimes applied to a vein, containing tin or copper.

MACLED CRYSTAL. A hemitrope crystal is sometimes thus called.

MAMMILLARY. Presenting a rounded or convex surface, like a small segment or portion of a large sphere. (See p. 51.)

MASSIVE. A mineral is said to occur Massive, when it has a crystalline structure, but not a regular form. (See p. 52.)

MATRIX. See Gangue.

MECHANICAL DIVISION. (See p. 9.)

MELLATE. A salt, in which the *mellitic* acid is combined with any base; as the Mellate of alumine.

METALLIC OXIDE. A metal, combined with *any* proportion of *oxygen*, is called a *metallic oxide*, provided it do not possess the properties of an acid. Hence the same metal, by uniting with different quantities of oxygen, often furnishes two or more oxides, which differ in color and other properties. Thus there are different oxides of iron, &c.—All metals must be converted into oxides, before they can combine with acids to form *metallic* salts.

METALLIC SALTS. Those salts, which have a *metallic oxide* for their base; of which carbonate of *lead* is an example.

MOLYBDATE. A salt, in which *molybdic* acid is united with some base; as Molybdate of lead, composed of molybdic acid and oxide of lead.

MOLYBDIC ACID. A compound of about 77 parts of *molybdena* and 33 parts of oxygen.

MURIATE. A salt, composed of *muriatic* acid and some base. Thus, Muriate of soda is a compound of muriatic acid and soda.

MURIATIC ACID. It is generally considered a compound of chlorine and hydrogen.

NATURAL JOINT. The plane, in which any two laminæ of a crystallized substance are united. (See p. 9.)

NITRATE. A salt, formed by the union of *nitric* acid with some base ; as Nitrate of potash, composed of nitric acid and potash.

NITRIC ACID. A compound of about 30 parts of *nitrogen* and 70 parts of oxygen.

NITROGEN. A simple, incombustible substance, formerly called azote.

OCTAEDRON. A solid, bounded by eight sides.

OXIDATE. To cause oxygen to combine with any substance.

OXIDATION. The act of combining oxygen with any substance.

OXIDE. Any substance, which contains oxygen, is called an *oxide*, provided the compound do not possess the properties of an acid. Hence water, composed of oxygen and hydrogen, is an oxide. But the term Oxide is applied chiefly to metals, combined with oxygen. —When only *one* proportion of oxygen is combined with a metal, the compound is called the *protoxide* (first oxide) of that metal ; when *two* proportions of oxygen are combined, it is called the *deutoxide* (second oxide), and so on. The highest oxide of any metal is called its *peroxide*.

OXYGEN. A simple substance, which, in most cases, is essential to combustion, during which it combines with the combustible. It is an essential ingredient of most of the acids. *Oxygen* constitutes, by weight, about 23 per cent. of *air*, and is necessary to the support of animal life ; the remaining 77 parts of air consist of nitrogen. *Oxygen* also forms, by weight, about 88 per cent. of *water* ; the remaining 12 parts being hydrogen.—Hence the *cause* of most of the changes, which minerals undergo by exposure to the weather, that is, to air and moisture ; the *oxygen* of the air, or of the water, or of both, combines with the metallic or combustible ingredients of the minerals, thus exposed, and produces oxides or acids, both of which may also enter into new combinations.

OXYGEN GAS. Solid oxygen, rendered gaseous by combining with caloric. This gas has been called *vital air*.

PARALLELOPIPED. (See p. 12.)

PEROXIDE. See oxide.

PHOSPHATE. A salt, composed of *phosphoric* acid, united with some base. Thus, Phosphate of lime is a compound of phosphoric acid and lime.

PHOSPHORESCENCE. A feeble light, which some minerals exhibit, when subjected to friction or the action of heat. (See p. 68.)

PHOSPHORIC ACID. A compound of about 45 parts of *phosphorus* and 55 parts of oxygen.

PHOSPHORUS. A simple, combustible substance, which burns at the common temperature of the air.

PHOSPHURET. This name is given to certain compounds, of which *phosphorus* forms one ingredient; as Phosphuret of iron, composed of phosphorus and iron.

PLUMOUS. Resembling a feather.

PRECIPITATE. Any substance, which, being previously dissolved in a fluid, is *disengaged* by the addition of another substance, and gradually falls to the bottom of the vessel.

PRISM, right; oblique, &c. (See p. 13.)

PROTOXIDE. See Oxide.

PSEUDOMORPHOUS. This epithet is applied to a mineral, when it has derived its form from that of some other substance. (See p. 52.)

PULVERULENT. When a mineral exists in the state of a powder.

RADIATED. When a mineral exhibits fibres or minute crystals, diverging from a centre, like the radii of a circle. (See p. 59.)

RECTANGULAR. In a rectangular prism, the sides form *right angles* with each other. (See p. 13.)

REDUCTION. When a metal, existing in the state of an *oxide*, either pure, or combined with an acid, is brought into a *metallic state*, it is said to be *reduced*. This reduction is effected by simply fusing the oxide, or by fusing it on charcoal, which abstracts the oxygen, or by fusing it with fluxes.

REGULUS. (See p. 524.)

RENIFORM. Resembling the kidney in form.

RETICULATED. When fibres or crystals cross each other, like the threads of a net. (See p. 33.)

RHOMB. A solid, bounded by six equal rhombic faces, meeting each other under oblique angles. (See p. 13.)

SALT. A compound, produced by the union of an *acid* with an alkali, or an earth, or a metallic oxide. The alkali, or earth, or oxide is called the *base* of the salt. If the name of the acid terminate with the syllable *ic*, the name of the salt terminates with the syllable *ate*. Thus carbonic acid, united with lime, forms carbonate of lime; and sulphuric acid, united with oxide of lead, forms sulphate of lead. But, if the name of the acid terminate with *ous*, that of the salt terminates with *ite*. Thus sulphurous acid, combined with iron, forms sulphite of iron.—Sometimes the acid and base do not saturate each other, so as to produce a *neutral* salt. In this case, if the *acid* be in excess, *super* or *bi* is prefixed to the name of the salt, as *super-phosphate* of lime; but, if the base be in excess, *sub* is prefixed, as *sub-borate* of soda.—It is obvious, that, in chemistry, carbonate of lime (limestone, chalk, &c.), or sulphate of iron (copperas, &c.) is to be considered a salt, as well as muriate of soda (common salt).

SCOPIFORM. When a mineral exhibits slightly diverging fibres, like a broom. (See p. 59.)

SILICEOUS. An epithet, applied to those earths or stones, which are characterized by the presence of silex, one of the earths.

SOLID ANGLE. It is formed by the meeting of three or more planes in one point.

SPECULAR. When a mineral presents a smooth brilliant surface, like a mirror.

STALACTITE. STALACTICAL. Like an icicle. (See p. 50.)

STELLATED. See Radiated.

STRIÆ. STRIATED. When a mineral is marked with minute channels or grooves, which often appear like straight lines, it is said to exhibit *striæ*, or to be striated. (See p. 53.)

SUBLIMATION. That process, by which a solid, as sulphur, is converted by heat into a gaseous state, and again condensed by cold.

SULPHATE. A salt, formed by the union of *sulphuric* acid with any base; as Sulphate of lime, composed of sulphuric acid and lime.

SULPHURET. This name is given to certain compounds, in which *sulphur* forms one ingredient. Thus, Sulphuret of iron is composed of sulphur and iron.

SULPHURETTED HYDROGEN GAS. A variety of Hydrogen gas, which holds sulphur in solution. It has a fetid odor, like that of putrid eggs.

SULPHURIC ACID. A compound of about 42 parts of sulphur and 58 parts of oxygen.

SULPHUROUS ACID. Its ingredients are the same as those of sulphuric acid, but with a less proportion of oxygen.

TRUNCATION. (See p. 29.)

USTULATION. The roasting of ores to drive off the sulphur or arsenic, or to volatilize any of the ingredients.

VESICULAR. When a mineral contains cavities, more or less resembling bubbles of air.

VITREOUS. Glassy.

EXPLANATION OF THE PLATES.

PLATE I.

- Fig. 1, 2, 3, 4. Mechanical division of a hexaedra prism of carbonate of lime. (See Introd. Art. 41, *p.* 10.)
- Fig. 5, 6. Mechanical division of a cubic crystal of fluat of lime. (See Introd. Art. 42, *p.* 12.)
- Fig. 7, 8. Mode of obtaining integrant particles by mechanical division. (See Introd. Art. 48, 49, *p.* 14.)
- Fig. 9, 10, 11. Construction of a secondary dodecaedron around a cubic nucleus; affording an example of decrements, parallel to the edges of the nucleus. (See Introd. Art. 58, *p.* 16.)
- Fig. 12. An Electrometer. (See Introd. Art. 169, *p.* 66.)

PLATE II.

- Fig. 1 to 11. Construction of a secondary octaedron around a cubic nucleus; affording an example of decrements on the angles, or parallel to the diagonals of the faces of the nucleus. (See Introd. Art. 65, *p.* 19.)
- Fig. 12. A Goniometer. (See Introd. Art. 74, *p.* 23.)
- Fig. 13 to 18. These figures are designed to illustrate the mode of describing crystals. (See Introd. Art. 83, 86, 87, 90, 91, 92, *pp.* 26 to 30.)
- Fig. 19, 20. These figures relate to hemitrope or twin crystals. (See Introd. Art. 97, *p.* 32.)
- Fig. 21. Nicholson's Portable Balance for estimating specific gravity. (See Introd. Art. 177, *p.* 70.)

PLATE III.

Crystalline Forms.

- | | |
|--|---|
| <p>Fig. 1, 2, 3, 4. Sulphate of Barytes.</p> <p>5, 6, Sulphate of Strontian.</p> <p>7. Phosphate of Lime.</p> <p>8. Fluat of Lime.</p> <p>9, 10, 11. Sulphate of Lime.</p> <p>12 to 22. Carbonate of Lime.</p> <p>23. Siliceous Borate of Lime.</p> <p>24. Borate of Magnesia.</p> | <p>Fig. 25, 26, 27. Topaz.</p> <p>28, 29. Sapphire.</p> <p>30, 31. Staurotide.</p> <p>32. Chrysoberyl.</p> <p>33, 34, 35, } Zircon.</p> <p>38, 39, }</p> <p>36, 37. Quartz.</p> |
|--|---|

PLATE IV.

Crystalline Forms.

Fig. 1, 2, 3.	Schorl.	Fig. 25.	Tremolite.
4 to 8.	Feldspar.	26.	Diopside.
9.	Scapolite.	27, 28.	Augite.
10, 11.	Axinite.	29, 30.	Hornblende.
12, 13, 14.	Garnet.	31.	Macle.
15, 16, 17.	Epidote.	32, 33.	Sulphur.
18.	Idocrase.	34.	Diamond.
19, 20.	Stilbite.	35, 36, 37.	Sulphuretted Antimonial Silver.
21.	Analcime.	38.	Argental Mercury.
22.	Chabasie.	39.	Sulphuret of Mercury.
23.	Harmotome.	40, 41.	Gray Copper.
24.	Chrysolite.		

PLATE V.

Crystalline Forms.

Fig. 1.	Blue Carbonate of Copper.	Fig. 24.	Arsenical Cobalt.
2, 3.	Sulphate of Copper.	25.	Gray Cobalt.
4.	Arsenical Iron.	26.	Oxide of Manganese.
5 to 10.	Sulphuret of Iron.	27.	Sulphuret of Arsenic.
11, 12, 13.	Specular Oxide of Iron.	28.	Sulphuret of Antimony.
14.	Sulphate of Iron.	29, 30.	Ferruginous Oxide of Tungsten.
15.	Carbonate of Lead.	31, 32, 33.	Red Oxide of Titanium.
16.	Sulphate of Lead.	34 to 38.	Silico-calcareous Oxide of Titanium.
17, 18.	Molybdate of Lead.	39.	Octaedral Oxide of Ti- tanium.
19, 20, 21.	Oxide of Tin.		
22.	Oxide of Zinc.		
23.	Sulphuret of Zinc.		

PLATE VI.

Geological map of the United States.

In this map, *geological* boundaries are applied to a *geographical* map, recently published by Cummings and Hilliard.

Alluvial Deposits are painted *gamboge yellow*.

Primitive Rocks *vermillion red*.

Transition Rocks *rose red*.

Secondary Rocks *pale blue*

Where no color is applied, the limits are uncertain; or the rocks, belonging to the two contiguous classes, are more or less intermixed.

INDEX.

Whenever a subspecies, variety, or subvariety has received a distinct name, it is arranged under the initial letter of that name. Thus, Apatite, though a variety of Phosphate of Lime, is placed under A.—Compound names are also arranged under the initial letter of the first word, of which the name is composed. Thus, Red Oxide of Copper stands under R.—Those French and German names, which have not been adopted, as English words, in this volume, are printed in Italics.

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ERRATA.

The following errors have been observed. They were occasioned in part by want of sufficient opportunity for inspecting the proof-sheets, in consequence of the distance, at which the author resides from the place, where the printing was executed.

- Page* 16, *line* 6, for darticles read particles.
— 32, — last, for manpular read manipular.
— 222, — 20, for on read no.
— 230, — 11, for 102° 28' read 104° 28'.
— 233, — last of note, for 231 read 237.
— 371, — 18, after name insert Skorza.
— 393, — 11, for *traw* read *straw*.
— 457, in the paging, for 475 read 457.
— 495, — 25, for diamodd read diamond.
— 526, — 10, from bottom, for gray wacke read graywackē.
— 587, — 25, for * read †.
— 628, — 19, after gives insert lead.
— 762, — 2, from bottom, for Florida read Florida.

The spelling of Conestoga, the name of a creek in Pennsylvania, is probably incorrect.

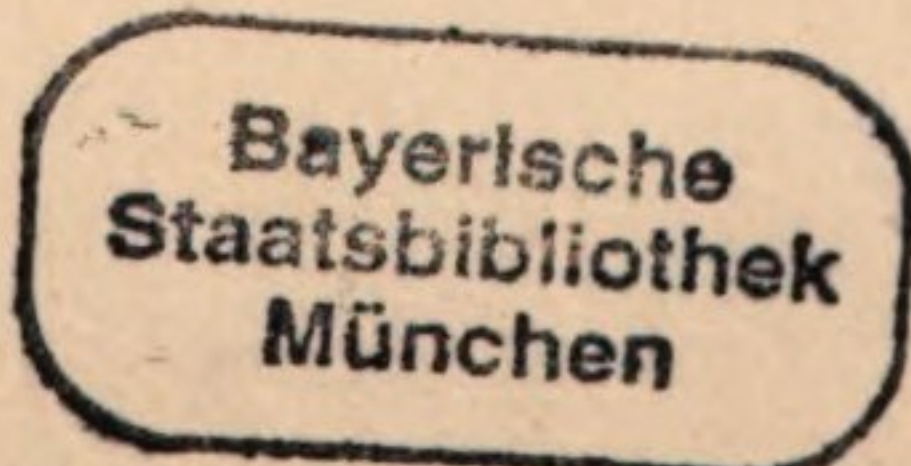


Fig. 4.

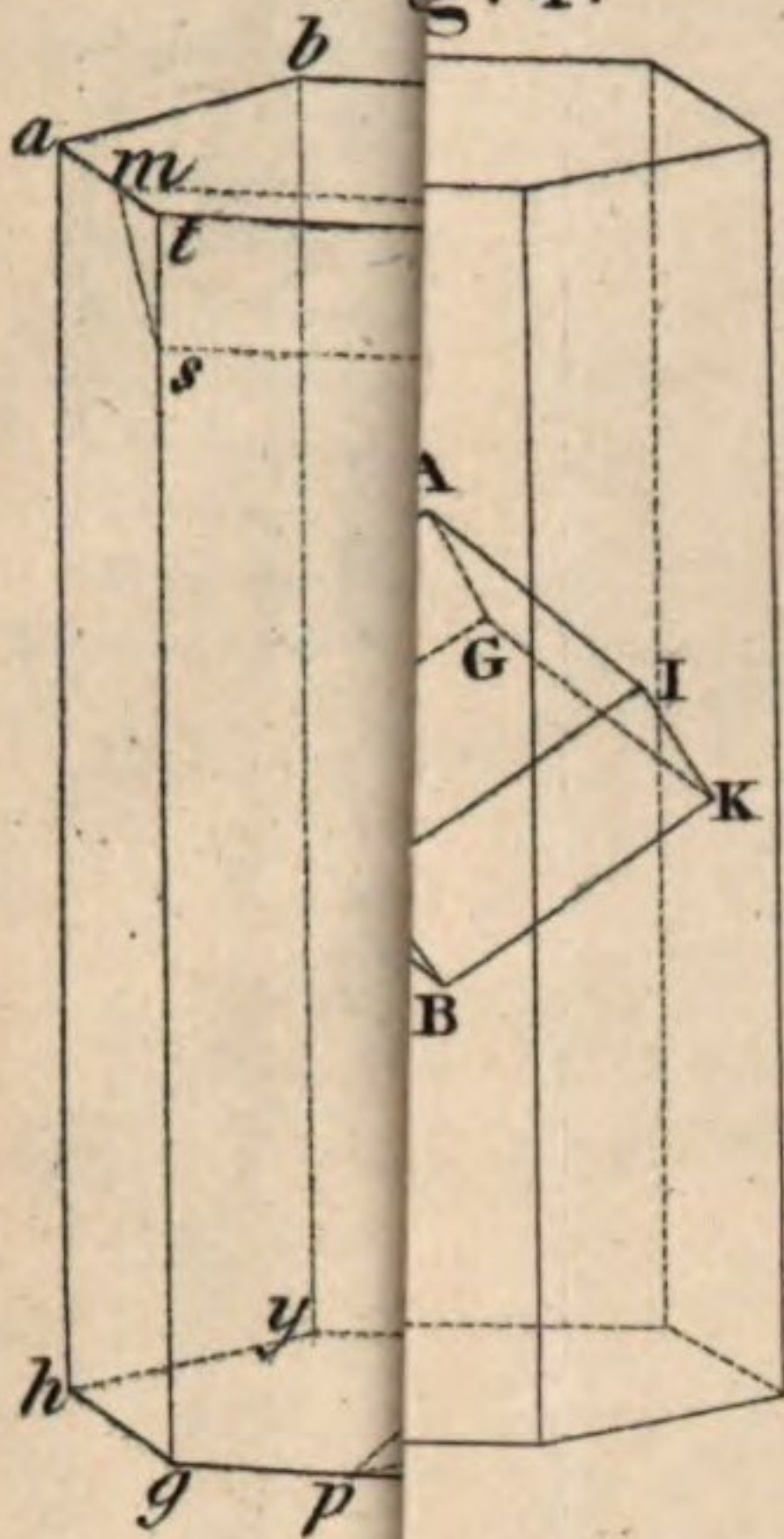


Fig. 5.

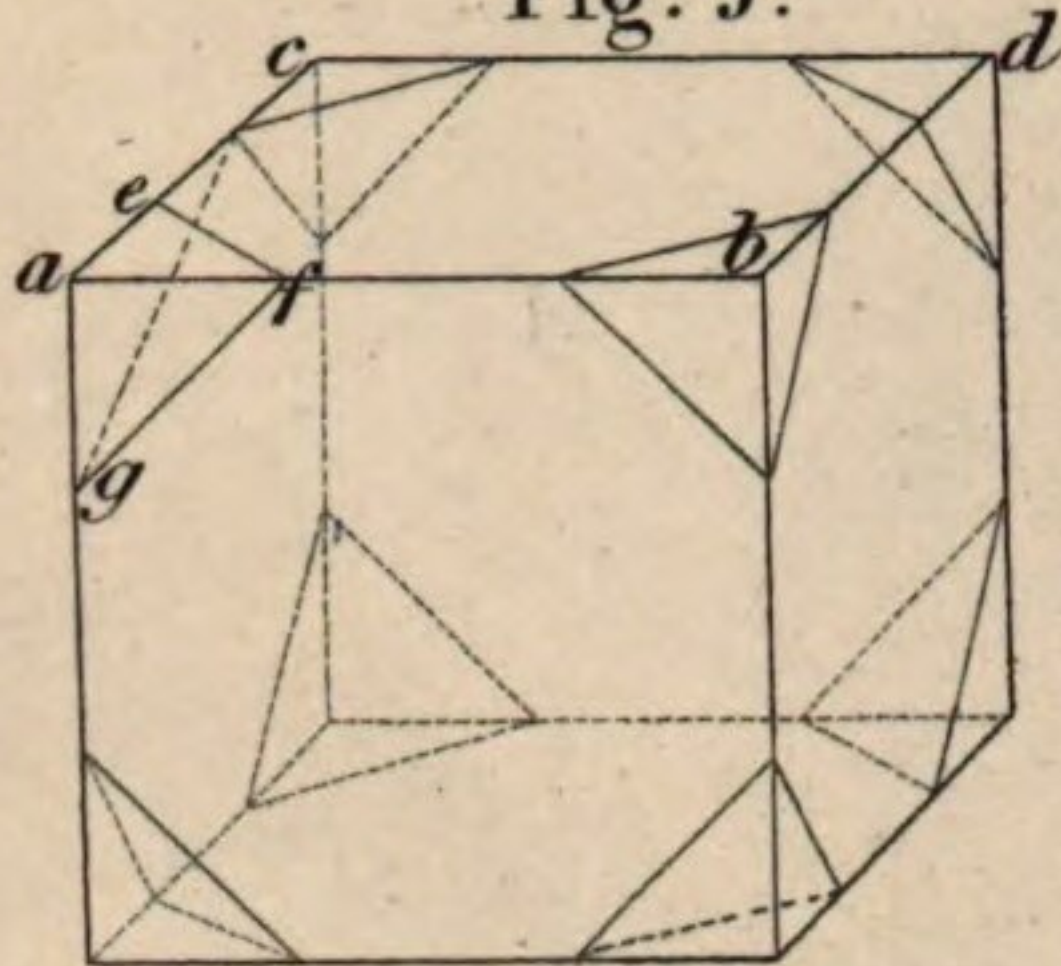


Fig. 6.

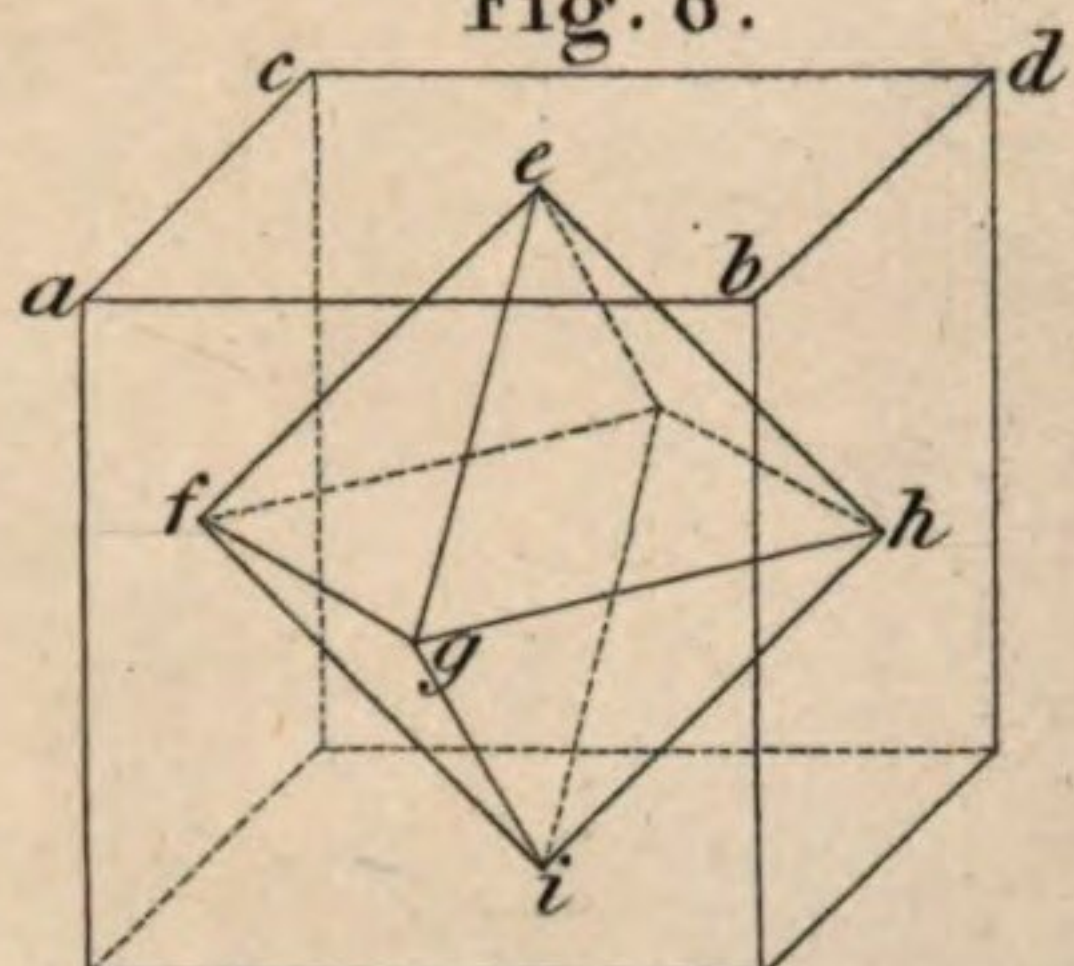


Fig. 7.

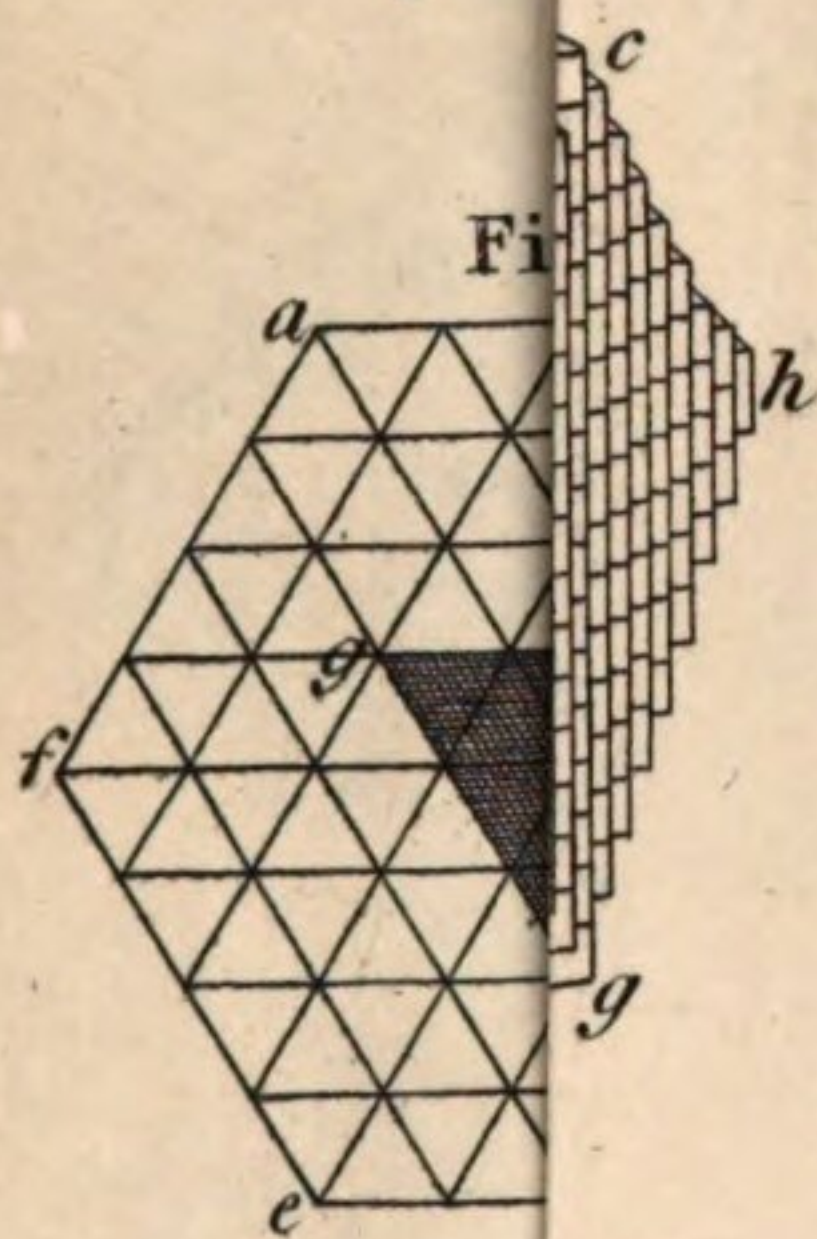
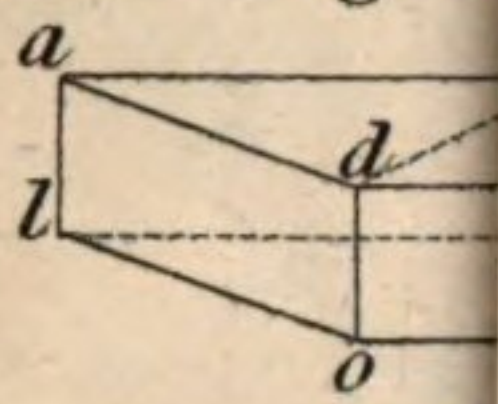
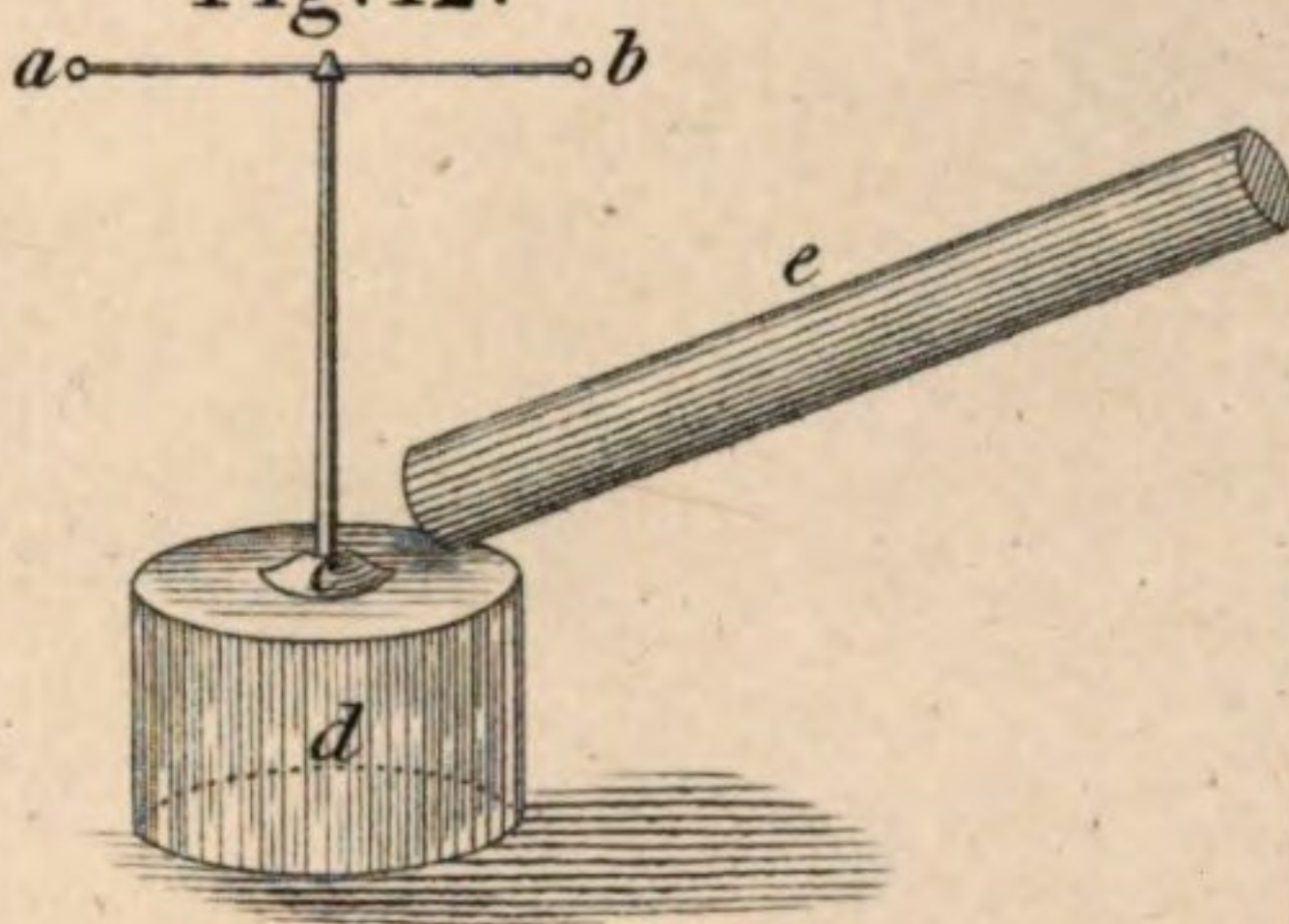


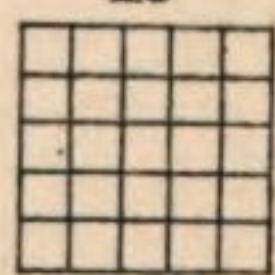
Fig. 12.



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Fig. 1.

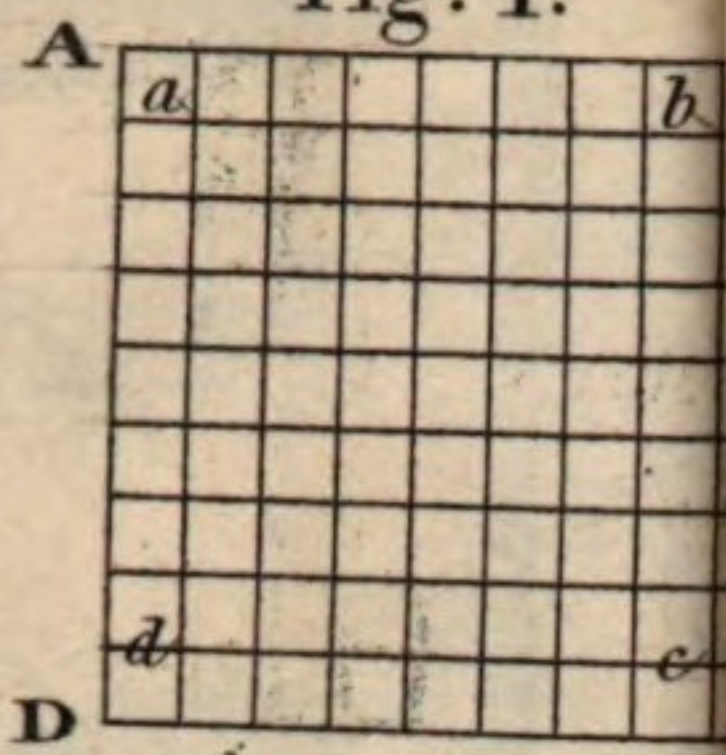


Fig. 5.

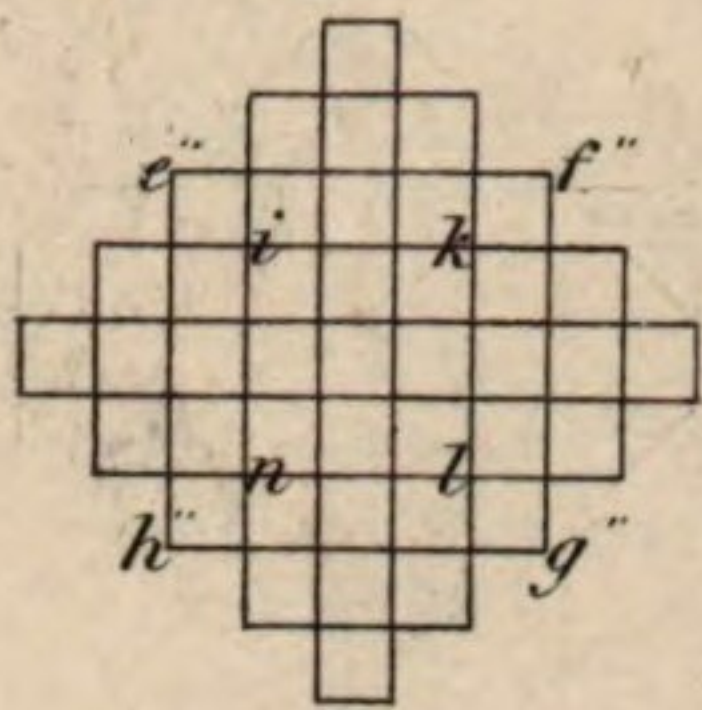


Fig. 6.

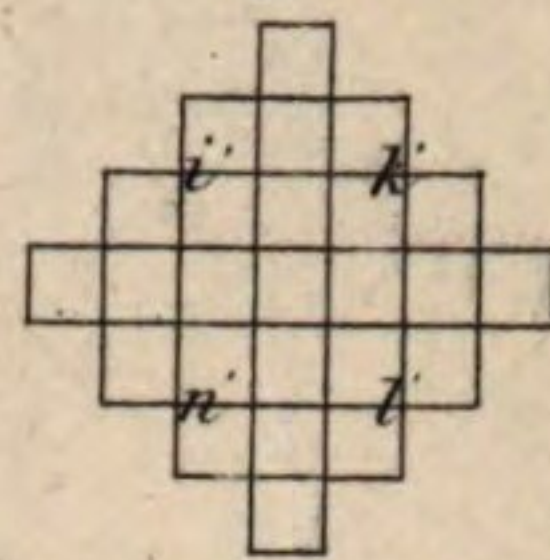


Fig. 1.

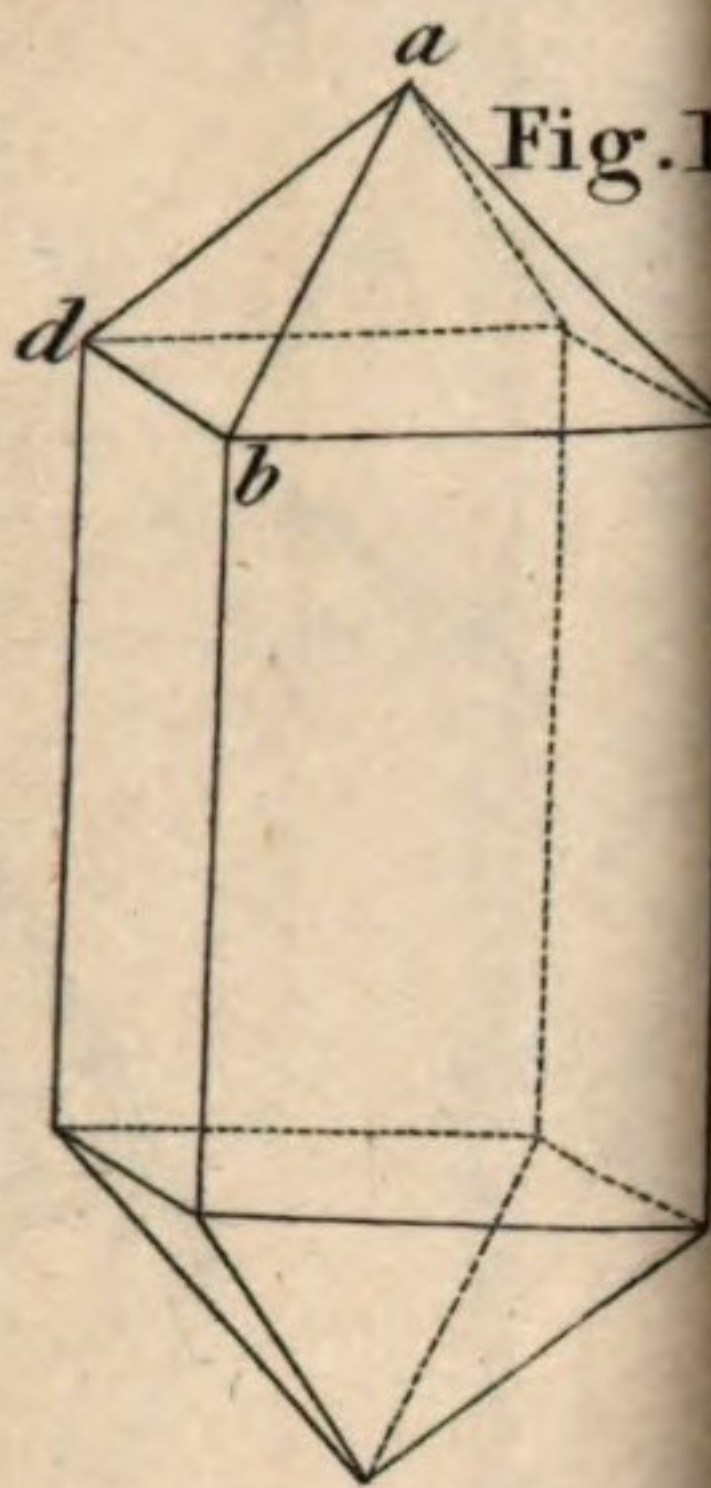


Fig. 7.

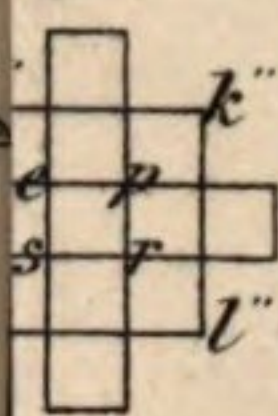


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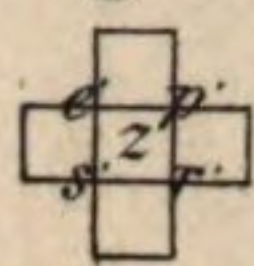


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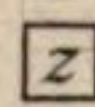


Fig. 15.

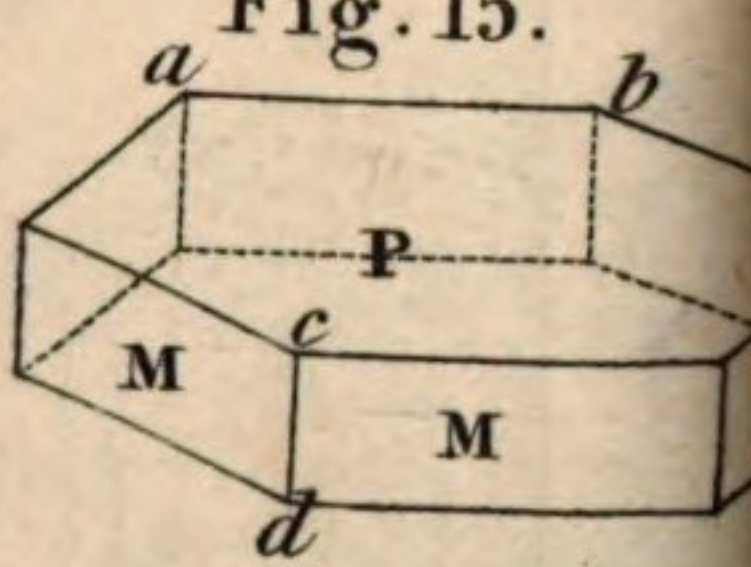


Fig. 13.

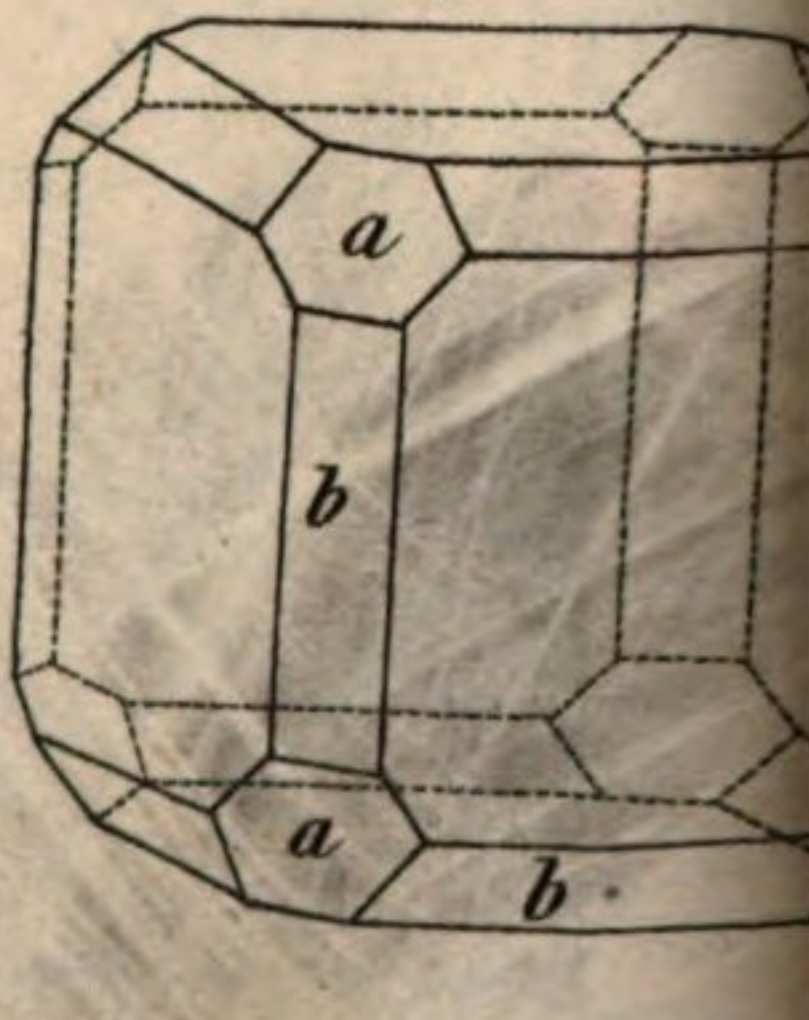


Fig. 19.

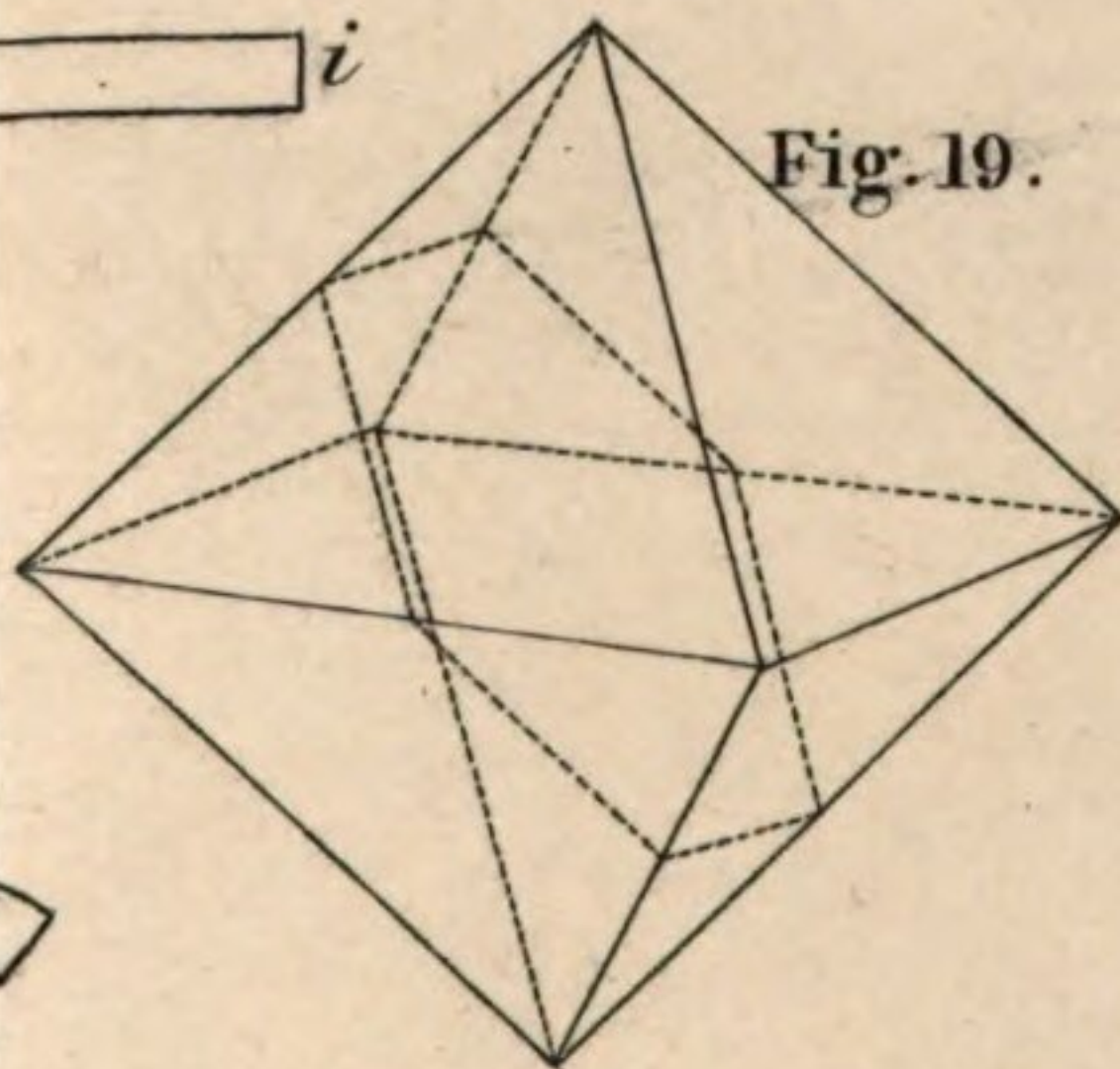
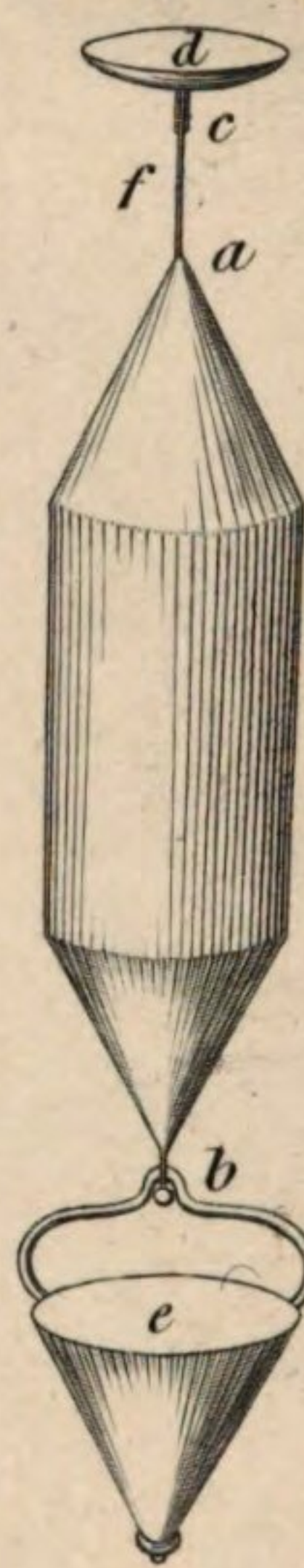
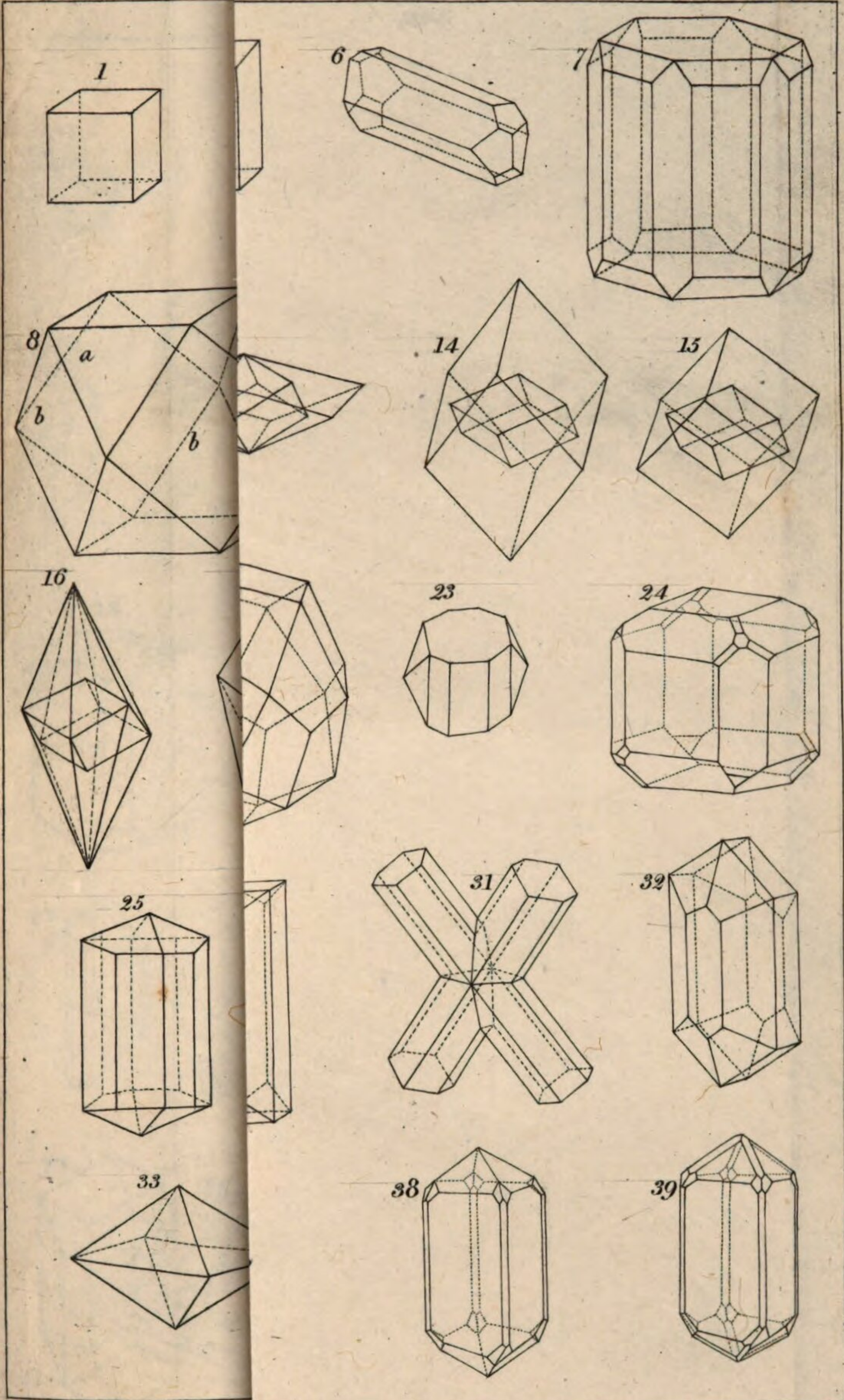
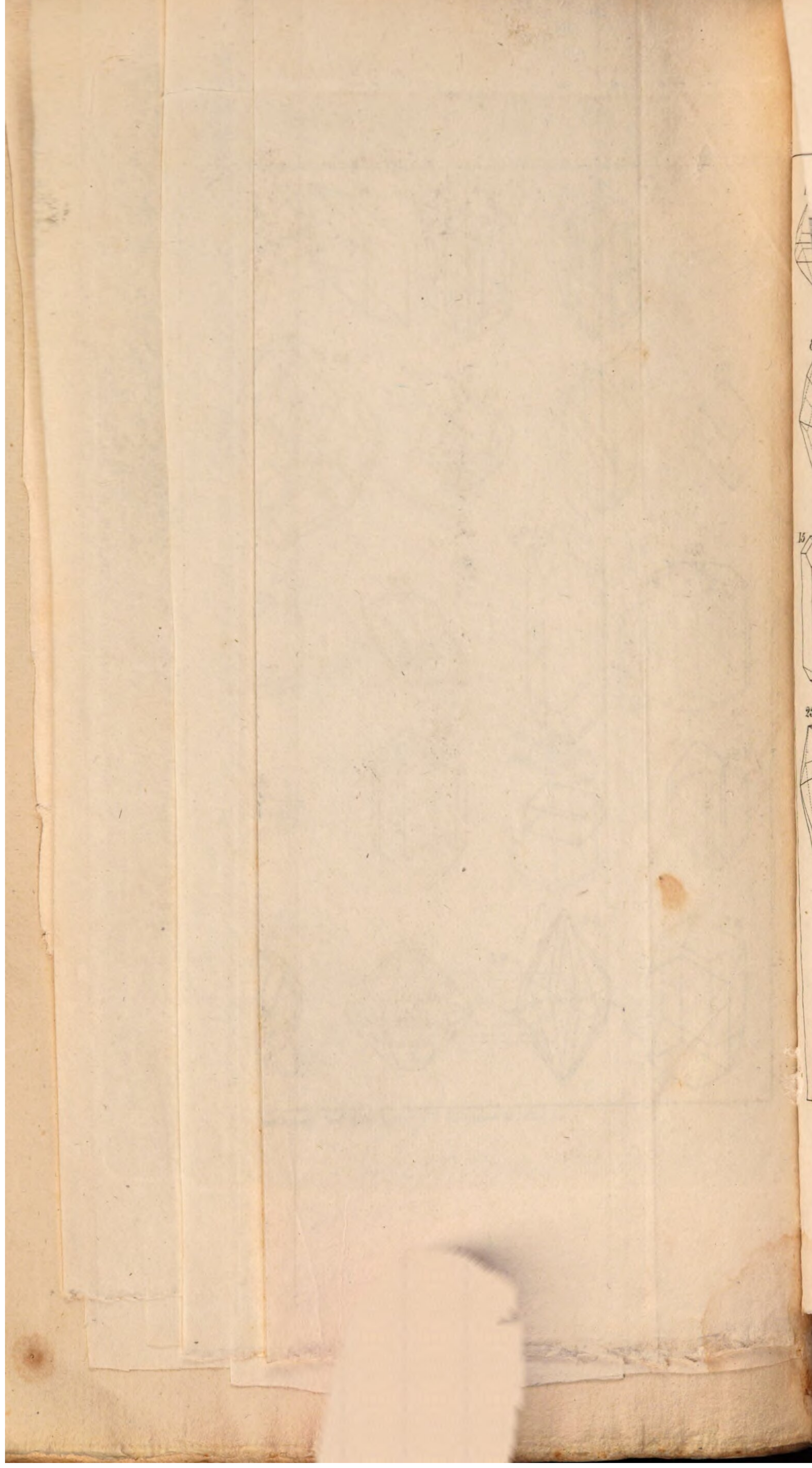
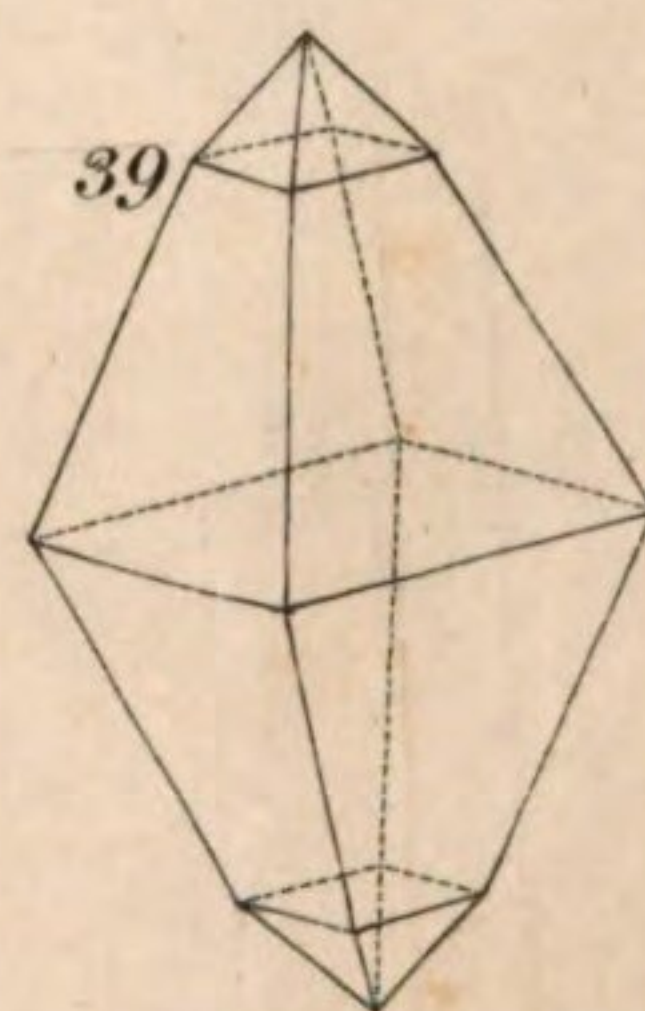
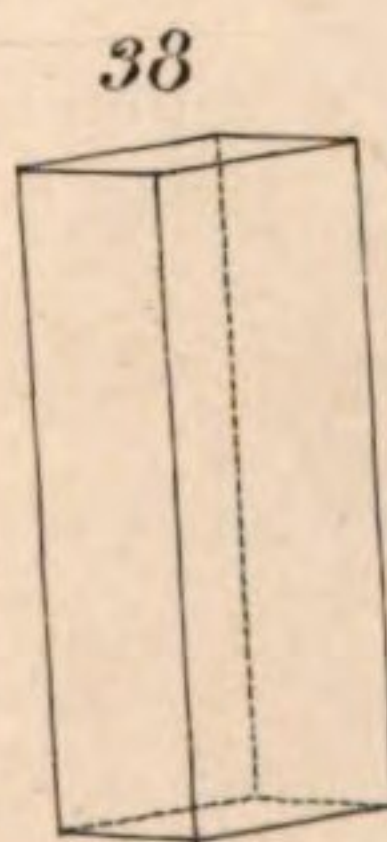
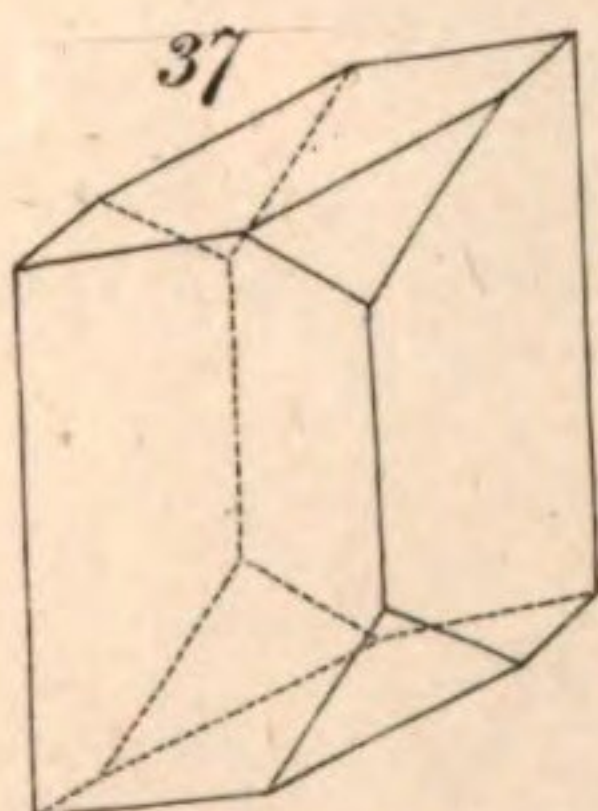
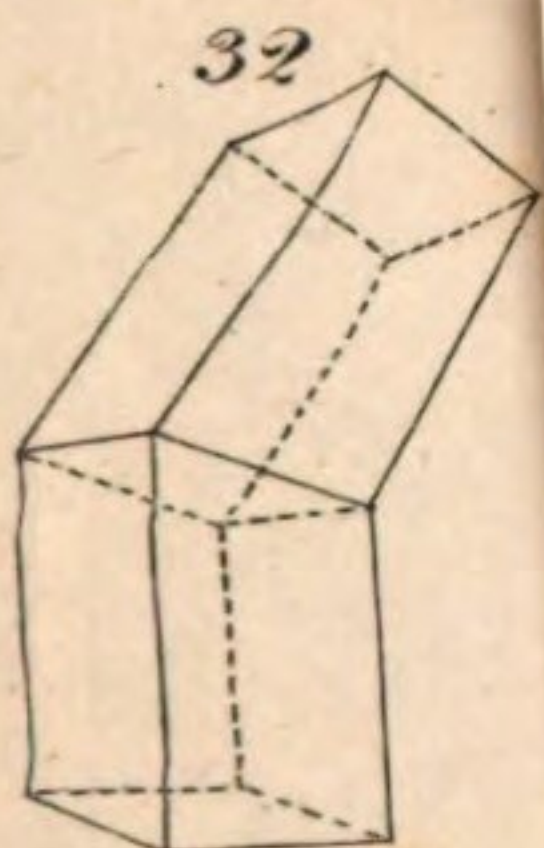
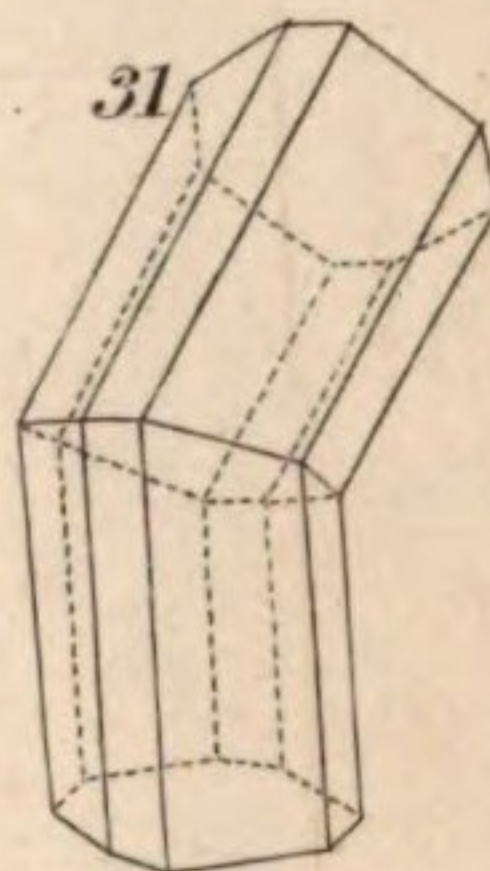
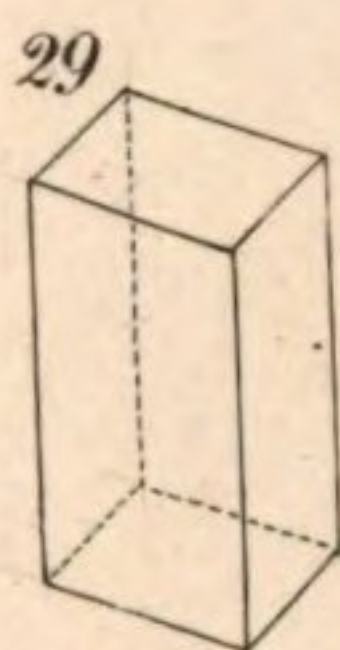
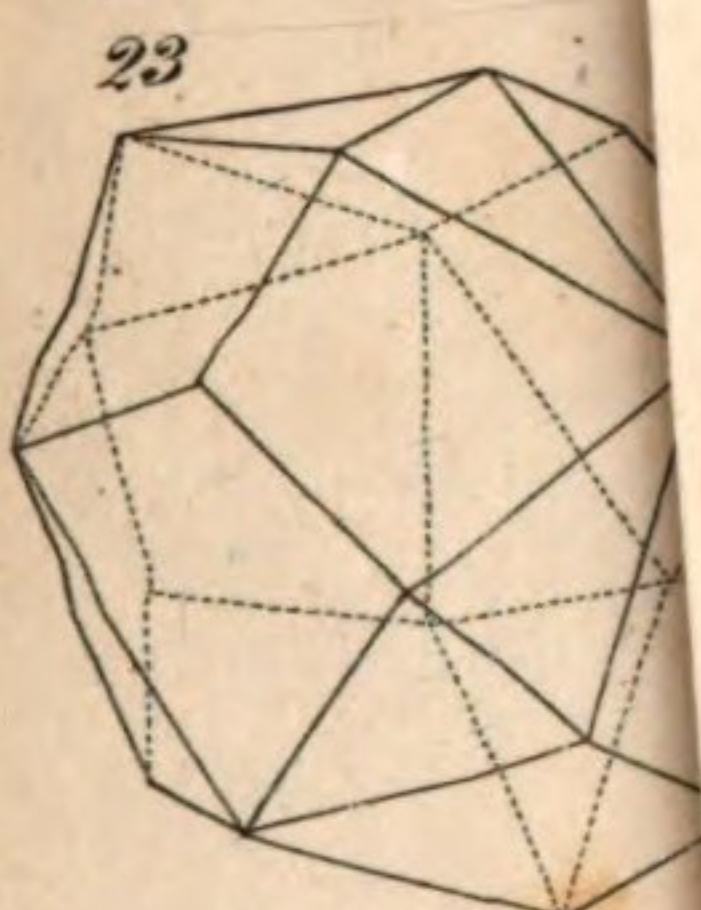
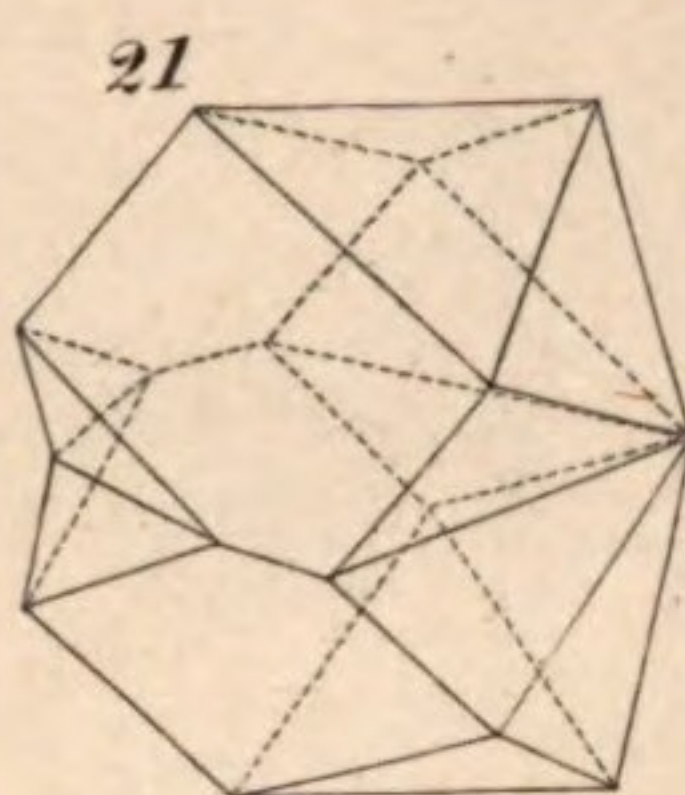
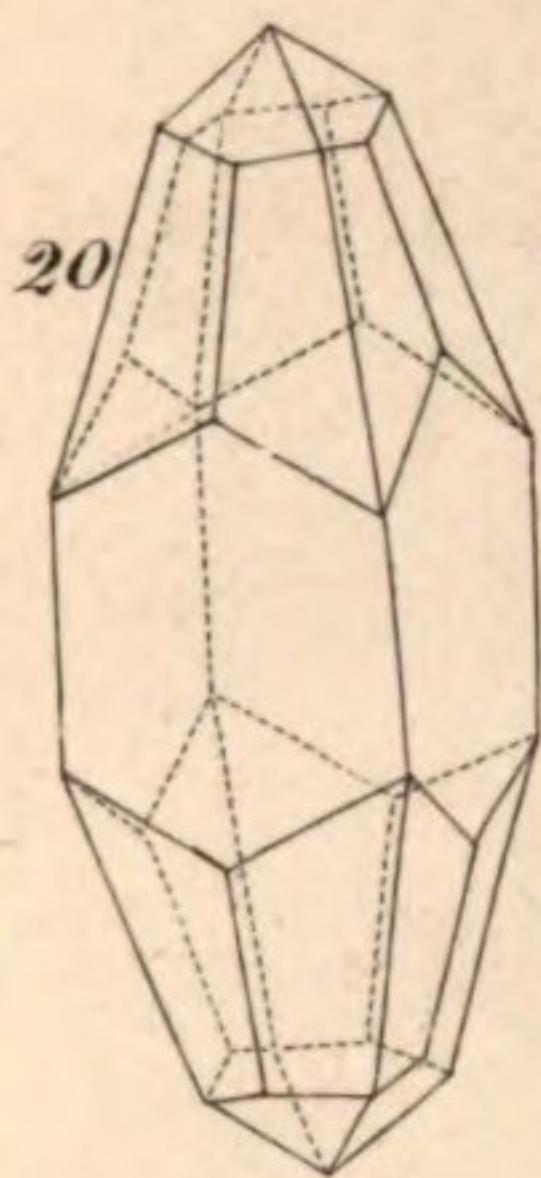
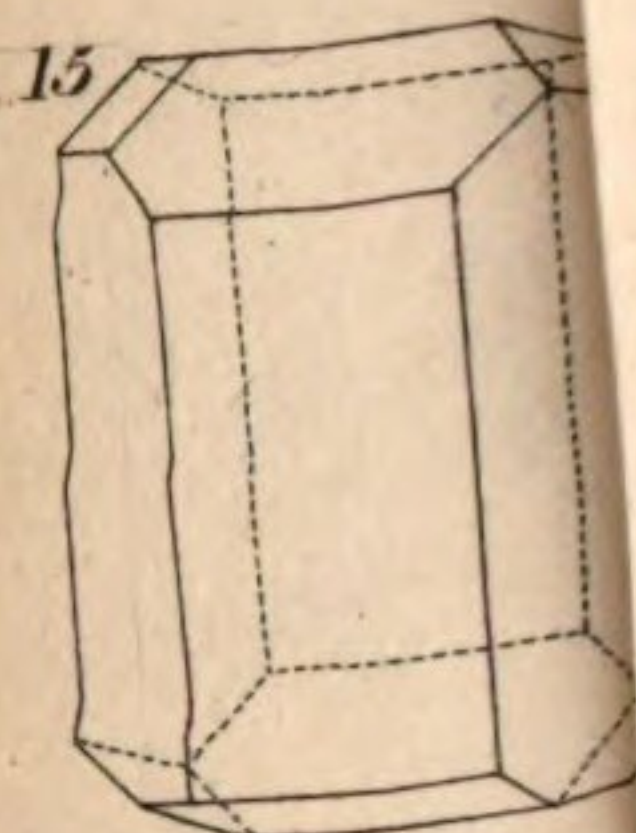
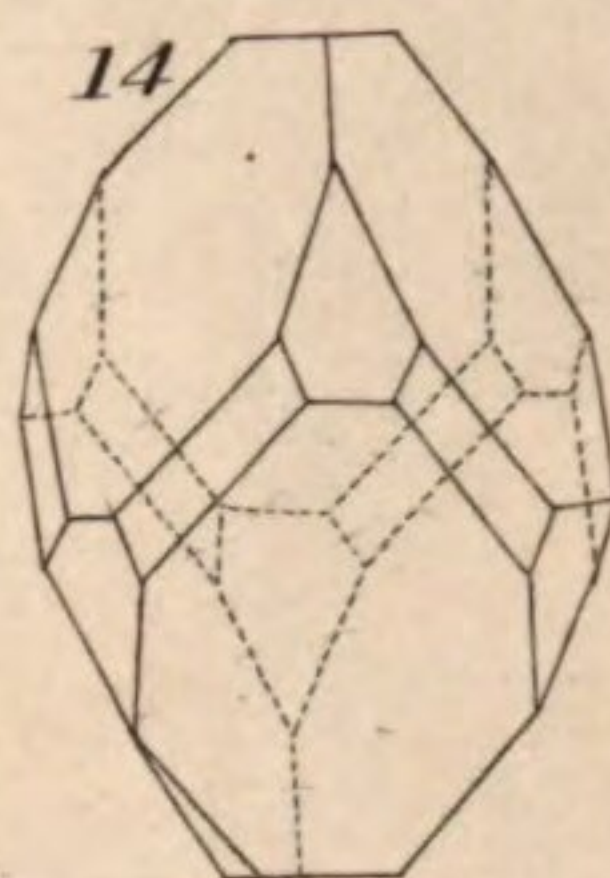
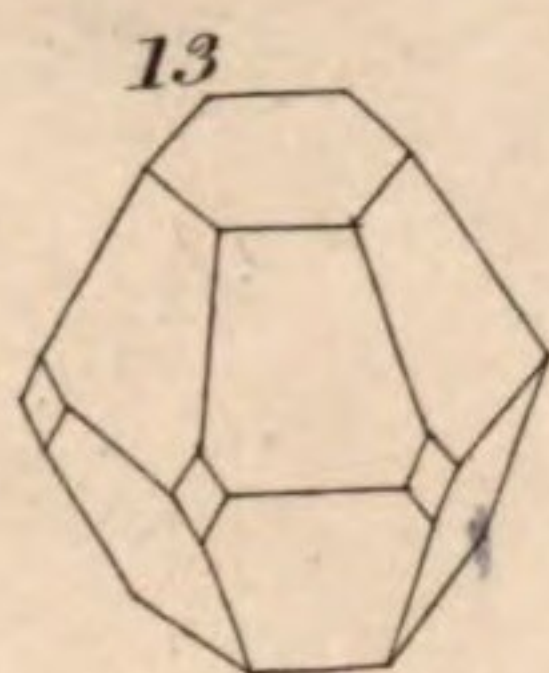
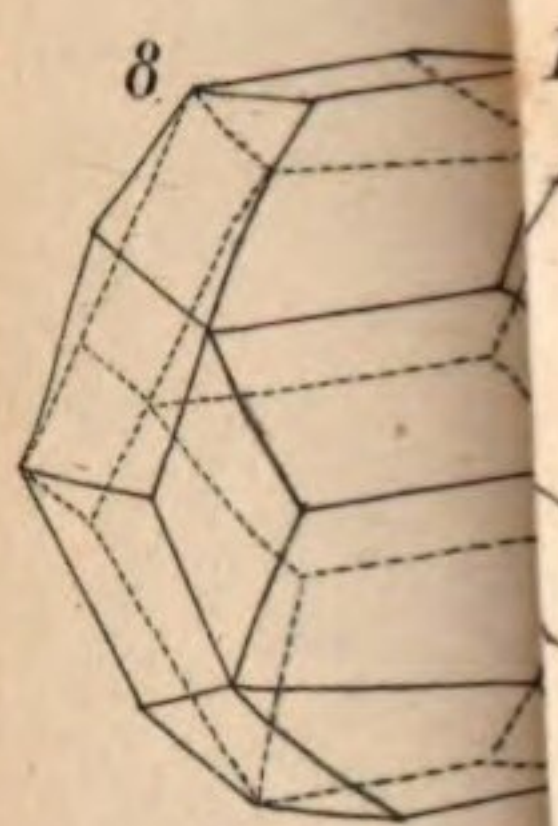
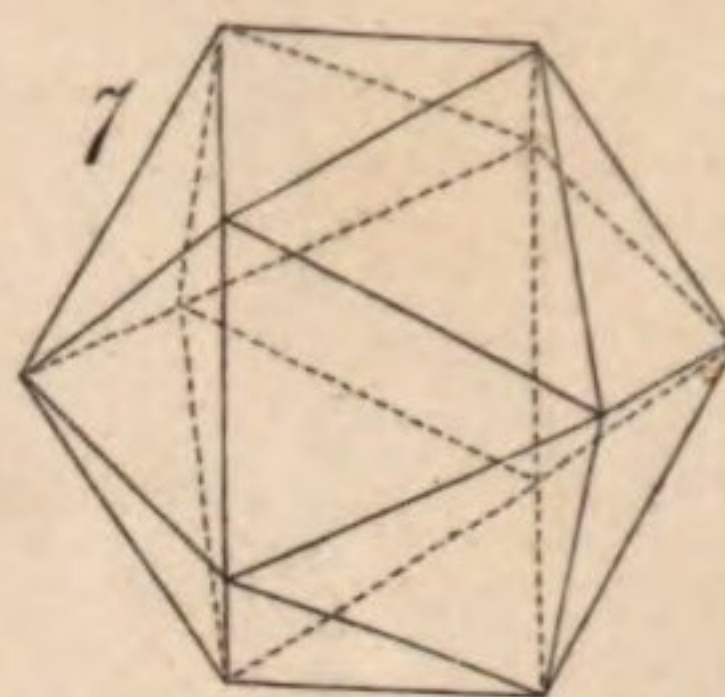
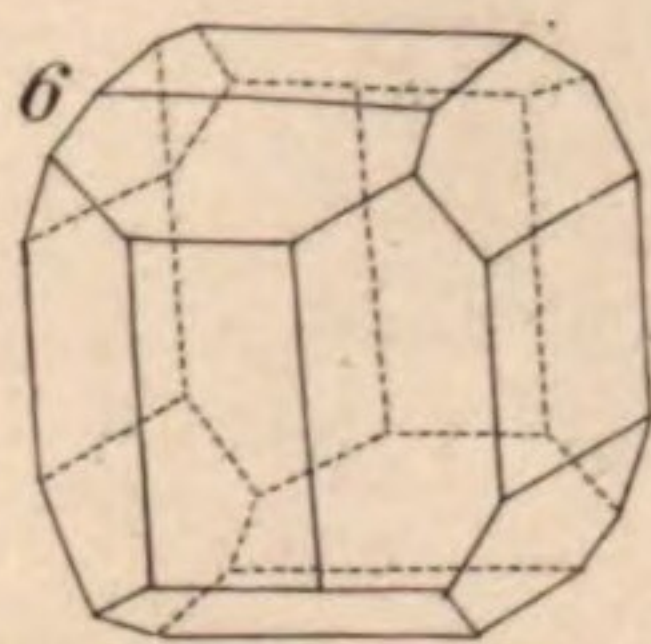
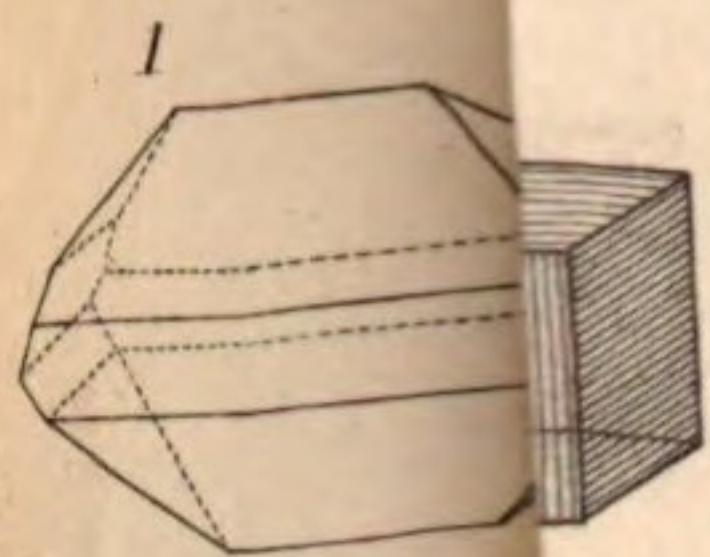


Fig. 21.









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